Grinnell

THE

JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY

OF ENGLAND.

VOLUME THE SIXTEENTH.

PRACTICE WITH SCIENCE.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1856.

These experiments, it is true, are not easy; still they are in the power of every thinking husbandman. He who accomplishes but one, of however limited application, and takes care to report it faithfully, advances the science, and, consequently, the practice of agriculture, and acquires thereby a right to the gratitude of his fellows, and of those who come after. To make many such is beyond the power of most individuals, and cannot be expected. The first care of all societies formed for the improvement of our science should be to prepare the forms of such experiments, and to distribute the execution of these among their members.

Von Thaer, *Principles of Agriculture.*

London: Printed by William Clowes and Sons, Stamford Street, and Charing Cross.

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The Binder is desired to collect together all the Appendix matter, with Roman numeral folios, and place it at the *end* of each volume of the Journal, excepting Titles and Contents, which are in all cases to be placed at the *beginning* of the Volume: the lettering at the back to include a statement of the *year* as well as the *volume*; the first volume belonging to 1839-40, the second to 1841, the third to 1842, the fourth to 1843, and so on.

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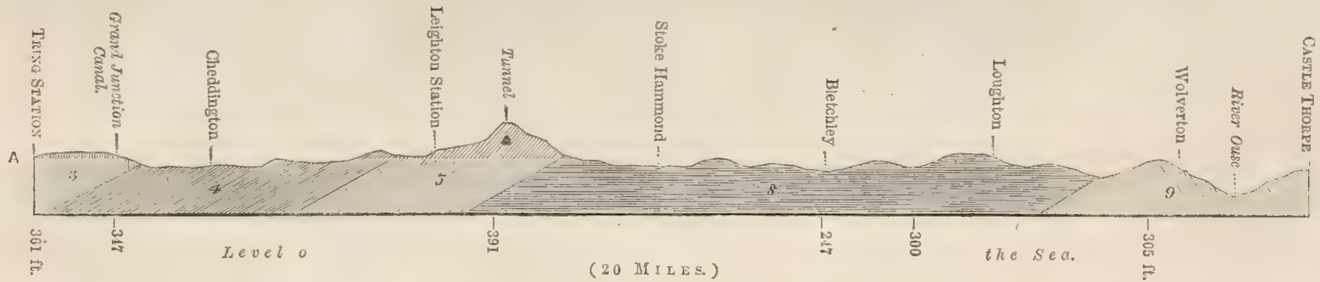

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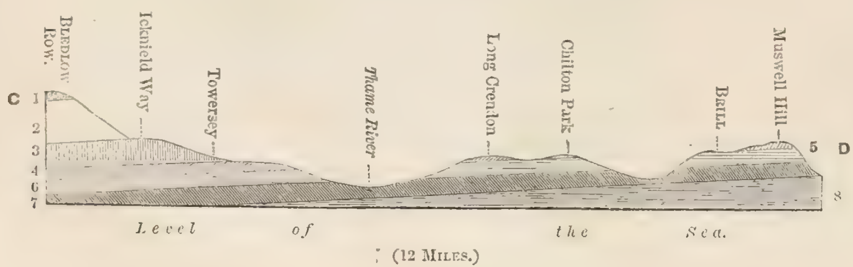

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6. Portland Oolite.
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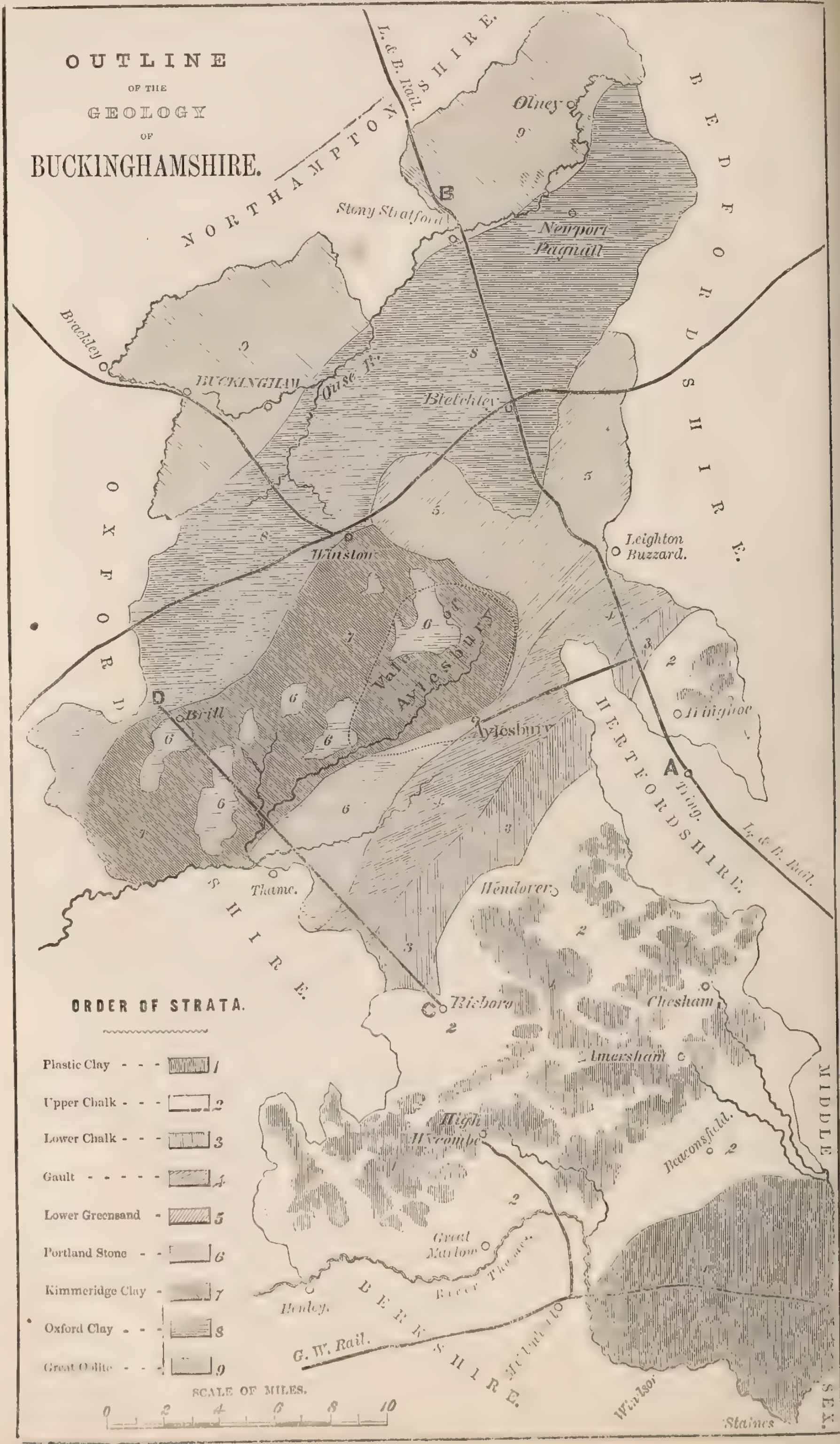
1 2 3 4 5



OUTLINE
OF THE
GEOLOGY
OF
BUCKINGHAMSHIRE.
NORTHAMPTON SHIRE.
BEDFORDSHIRE.
OXFORDSHIRE.
HERTFORDSHIRE.
BERKSHIRE.
MIDDLESEX.
L. & B. Rail.
G. W. Rail.
Olney
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Brackley
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Ouse R.
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Upper Chalk 2
Lower Chalk 3
Gault 4
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Portland Stone 6
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SCALE OF MILES.
0 2 4 6 8 10

JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

I.—*On Lameness in Sheep and Lambs.* By Isaac Seaman.

Prize Essay.

THOSE frequent and formidable diseases, the causes of which we are about to investigate, cannot be too well understood by all persons whose time and capital are employed in breeding and feeding that valuable animal the sheep.

The term lameness is applied to a symptom that marks all cases where any impediment is offered to the free and natural action of the limbs: it signifies being crippled or disabled; therefore all affections of any of these parts, whether arising from constitutional or other causes, alike claim the strictest attention.

Disease of the foot and leg of the sheep commonly occurs in a variety of forms and under various circumstances, often prevailing to such an extent that great losses are thereby incurred. Lambs are frequently known to die from its effects, and a much greater number are so reduced in condition, their limbs so impaired and crippled, that weeks, even months, elapse before the injured parts can be restored so as to perform their proper functions. The joint-disease in lambs destroys yearly its thousands; the foot-disease is often extremely prevalent, and, although but seldom attended with loss of life, flocks among which it breaks out rapidly lose flesh and become much reduced in value. From the year 1840 to 1847 inclusive, vesicular epizootic (the mouth and foot disease) raged so extensively that whole herds of cattle were seen moving along our highways from one market to another, with saliva and mucus flowing from their mouths, and with their limbs crippled, the hoofs having lost their attachment, and matter exuding from the coronets. From this disease our pigs, too, suffered. It was no unfrequent occurrence to see them crawling about our farmyards upon their knees, the hoofs having lost the

power to support the body, being about to slough, while in some cases they had fallen off, leaving the very sensitive and denuded parts of the foot exposed to friction from surrounding bodies, causing excessive pain and suffering to the animal. From this disease our flocks also suffered, and their value soon diminished, two or three months being often required to restore them to their former condition. The feet of these animals were the parts principally affected, inflammation often pervading the entire organism of the foot, followed by all its too common results—suppuration, ulceration, and gangrene—appearances which, to a careless observer, would be characteristic of a very severe case of foot-rot. The circumstance of disease affecting the different structures of the foot and leg, and producing different actions of the limb, has induced the observation amongst us that there are different kinds of lameness, meaning that disease, in the different structures of a limb, is attended with a motion peculiar to that diseased condition; for example, when the hip, stifle, and hock-joints are affected, there is a dragging of the toe along the ground; whereas, where the parts below the hock and behind the leg (the fetlock and foot) are the seats of disease, the toe is fairly lifted and carried forward, and lameness is not seen until the weight of the body is thrown upon the affected side. In other cases we see the leg carried outward, forming a circle, and in others inwards, in the same rotary manner. Disease of a limb, like disease of any other organ, may be distinguished by the terms idiopathic and symptomatic; the former being applied to that which takes its origin in the parts affected, excited by causes operating peculiarly upon itself, as foot-rot, being produced by a wedge of earth forcing itself between the crust and sole, and injuring the quick; the latter to that which owes its existence to constitutional causes, as the joint-disease in lambs, that originates through the body being exposed to cold and moisture. Lameness in sheep and lambs arises from many other causes besides those already mentioned; dirt occasionally finds its way down the interdigital canal, excites inflammation and much lameness—black-leg, set-fast, rheumatism, sprains, bruises, and broken leg, all of which are attended with lameness.

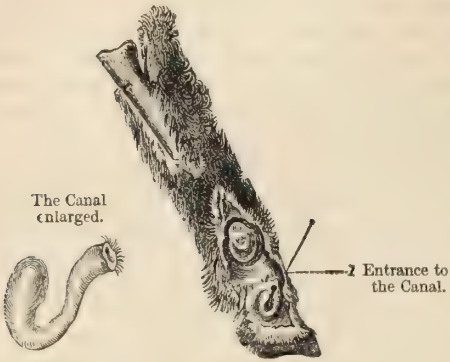
It is not usual for essays on diseases to contain an anatomical description of the diseased parts of which they treat; but in one of the present description, which is principally intended to be read by amateurs, and where disease of the foot forms so prominent a feature, I have considered it better to give an anatomical description of that organ, from a knowledge of which the reader will readily comprehend the more important part, the nature and treatment of the foot in a diseased condition.

Anatomy of the Foot.

The foot of the sheep presents us with an arrangement of structure well adapted to the natural habits of the animal: it is divided into two digits, or toes, each having an outer covering of hard insensible substance, called hoof. The hoof is principally divided into crust and sole: the crust, extending along the outer side of the foot round the toe, and turning inwards, is continued about half way back between the digits on the inside; the sole forms the lower bearing of the foot, and fills the space between the inner and outer borders of the crust; it continues backwards, becoming softer as it proceeds, and terminates at the heel, upon an elastic pad, similar in structure to the frog of the horse. This diversity of structure (as observed by one of our learned veterinary professors) is for particular purposes. The crust, like that in the hoof of the horse, being harder and tougher than the sole, keeps up a sharp edge on the outer margin, and is mainly intended to resist the wear and tear to which the foot of the animal is exposed; the sole covering the heels, although apparently soft, is tough and elastic, like India-rubber, and has the power to resist laceration from the sharpest bodies; hence its great use, not only in preventing injuries to the more sensitive parts beneath, but injuries from concussion when the animal has leaped from an eminence; it also assists in giving the sheep a firm footing whilst travelling over rocky and mountainous countries, of which many of our breeds are natives.

The hoof being separated (which may readily be done by placing the foot in boiling water for a few minutes), we expose the coronary ligament, the laminæ (the adjoining structures to the crust), the dense elastic pad upon the heels, and the villæ, or spongy-like structure, connecting the sensible with the insensible sole. The coronary ligament passes round the upper part of each digit, and serves to connect the common skin of the leg with the internal parts of the foot, and adheres closely to the upper part of the insensible crust and sole; it is formed by dense fibrous tissue, interwoven by innumerable blood-vessels; and from this structure the hoof is formed. Beneath these parts we find the coffin bones below, the coronary bones above, and the navicular bones behind, the ligaments or bands by which these bones are connected, the joints and their beautiful lining, the synovial membrane, and the smooth, polished substance called cartilage, by which the joint-ends of bones are formed. About an inch above the foot, in the centre and front, we find a small hole (1) piercing the skin, called the interdigital canal; this tube, or canal, passes downwards and backwards (as shown in diagram) between the toes, imbedded in cellular tissue and fatty

matter: it enlarges as it proceeds; its lower end curves upon itself, and terminates in a blind pouch. Mr. Youatt, in his work on Sheep, p. 225, in describing this canal, says, "it divides immediately on entering the skin, sending a branch to the front of each toe;" hence its generally received name, the biflex canal. I have dissected numbers of sheep's feet, but have never discovered a divided interdigital canal. The internal lining of this tube is covered with hair, and thickly studded with sebaceous glands, which secrete a smooth, viscid fluid; this, flowing from the external opening, runs down between the digits, lubricating the parts, and answers the two-fold purpose of preventing friction from the toes rubbing against each other, and also prevents dirt adhering to the skin between them, and getting hard and dry, which would be a source of great irritation to the animal.



Diseases of the Foot.

I. *Common Foot-rot, or Gravel.*—This disease consists in inflammation, more or less extensive, of the internal structures of the foot, the formation of matter, its exudation at the top of the hoof, the separation of a portion or all of the crust and sole from the parts beneath, sinuses or holes penetrating more or less deeply into the foot having been formed, which causes extreme lameness of the limb, whilst the foot is very hot and painful, and points forward. In its commencement it is purely local and easily cured by surgical means, and is non-contagious.

Causes.—It frequently proceeds from bruises received upon the coronet, and from thorns or other sharp bodies piercing the sole and injuring the quick. In some cases, in the first stage of the disease, there is often found nothing but the edge of the crust, forced asunder from the sole; a wedge of earth collects and presses upon the sensitive parts beneath, and is a frequent excitant of foot-rot: but it most frequently occurs in sheep that have been placed in low swampy pastures, where the hoof, becoming softened by continual immersion in moisture, grows luxuriantly and unrestrained. In this condition it is unable to stand against the opposing friction of a harder ground surface; hence, when the

sheep is placed upon a dry upland pasture, or driven a distance on stony roads, the softened heels become bruised, inflammation is set up in the sensitive parts of the foot, matter forms, and the sheep suffers acute pain and lameness: the crust at the toe having grown very long, it either curves inwards and forms an under or artificial covering to the sole, serving to accumulate and retain earth and filth, or is broken off in detached parts, in some cases exposing the quick or opening new pores, into which particles of earth and sand force their way, until, reaching the quick, matter forms in one or more of the digits; the attachment between the sensible and insensible parts of the foot is destroyed, whilst the matter ascends and breaks out upon the heel, or outside of the foot.

Treatment.—Treatment of the common foot-rot, or gravel, merely consists in removing all the hoof that has been separated from the parts beneath (a small pocket drawing-knife will be the best instrument for this purpose), taking care not to injure the sensitive parts of the foot, which would certainly aggravate inflammation. Wash the foot with a solution of alum, in the proportion of half an ounce to a pint of water; cover the denuded parts with the oxide of zinc, over which place a pad of tow and bandage of broad tape or calico. This dressing, repeated at intervals of two or three days, will speedily effect a cure. If a number of sheep are affected at the same time, and the plan of covering the foot appears too tedious, the flock may be placed in a dry situation for three or four hours after each dressing: a dry heath, a rough upland dry pasture, or a fold, the bedding of which is thickly covered with straw, will be found to answer well. If unhealthy granulations (proud flesh) spring up, and the above application proves inefficient to reduce them, and there is an indisposition in the healthy horn to form, which commonly happens in such cases, the parts occupied by proud flesh may be slightly touched with a red-hot iron and have a covering of tar and tow applied, the foot and leg being bandaged; or, instead of the hot iron, a powder, composed of equal parts of linseed-meal and blue vitriol, will be found beneficial. These dressings, repeated about twice a-week, will never fail to effect a cure: great care is necessary that no part of the foot but that occupied by proud flesh be touched with the hot iron or vitriol. Such dressings are required only when the flesh appears spongy or unhealthy, for the too frequent application of caustics retards recovery.

II. *Epizootic Foot-rot, or Murrain.*—Epizootic foot-rot (or murrain) consists in inflammation of the skin connected with the hoof (involving the laminæ and villæ), the formation of blisters upon the heels and between the digits, which in three or four days break and expose deep red, inflamed, and tender surfaces;

these for a short time discharge a thin serous fluid, or, as it is sometimes called, moult-water. In a few more days ulcers begin to form, and a discharge of white matter commences, emitting a most offensive odour. The two fore feet are those generally affected, and sometimes the hinder ones; the sheep is extremely lame, and walks upon its heels. In cases of epizootic foot-rot no time ought to be lost in applying proper remedies, for, the ulcerative stage having commenced, the groundwork of a disease may be laid that will often require weeks or even months to remove. As soon, then, as the sheep appears lame, it should directly be removed to a dry and clean situation. Cleanse the foot from all dirt by carefully washing it with soap and water, and apply with a piece of tow a lotion composed of two drams of blue vitriol to a pint of water; keep the tow on by means of a bandage. Administer to the sheep four ounces of Epsom salts and an ounce of yellow sulphur; in two days more give half an ounce of nitre and the same quantity of sulphur: the sulphur and nitre, given once a week, will be found very beneficial. Apply the vitriolic lotion twice a week, and at each dressing be careful to remove all detached portions of hoof.

Having described the manner in which the disease progresses, and its treatment, I would observe that, if the sheep is under the care of an ignorant shepherd or careless owner, and the case is allowed to proceed without remedial treatment, the coronet will become much swollen, the foot will appear to swing in the air, and, the toes being forced from each other by the swelling that exists between them, matter and sinuses will form, which, running in various directions, will gradually detach the whole hoof. Ulceration rapidly progresses, it eats deeply and spreads on every side, inflammation is extensive, the sheep takes no food, she loses flesh fast, and there is excessive irritation of the whole system. The ravages from disease at this period are frightful and utterly unmanageable, except in the hands of the skilful shepherd or surgeon. The foot must be examined minutely, and every part of separated hoof must be removed; but on no account cut away indiscriminately every piece of horn that presents itself, whether separated or not, for this is a common practice with shepherds. Hoof once separated will not again unite, but acts as a foreign body, and is a source of pain, inflammation, and fungous sproutings. Every particle of this, then, that is in the slightest degree separated from the parts beneath being cut away, let a warm turnip or carrot poultice be applied and renewed twice a-day for three days; place the sheep in a clean quiet situation, and administer four ounces of Epsom salts and a dram of laudanum: in three or four days the poultices may be omitted, and the vitriolic lotion, the tow, and bandage applied, in the same way as recom-

mended in the milder cases. If in a fortnight proud flesh grows too rapidly, and there is no appearance of healthy horn forming itself, the parts may be touched with lunar caustic, or with what is still better, the red-hot iron. Give the sheep occasionally a dose of salts and saltpetre, and keep down proud flesh with the caustic or hot iron, and in a few weeks a cure will be effected. I will again caution shepherds and others to apply caustics only where proud flesh has sprung up, and not to allow their butter of antimony, or any other of their favourite hot stuffs, to run over the whole denuded foot, for this always increases inflammation, and consequently delays the cure.

Causes.—This disease, when once propagated, will spread rapidly by contagion, that is, by contact with its morbid secretions. Infected sheep will communicate it to those that are sound. Sound sheep may become affected even by following diseased ones on a road, or by being placed in a field where an infected flock a few days previously had been.

Treatment.—When epizootic foot-rot breaks out upon a farm, it is not without some difficulty freed from it; however, its removal is accomplished more easily than some may be disposed to imagine. As soon then as the disease makes its appearance the whole flock should be moved to a part of the farm not used for feeding sheep, and those that are healthy should be separated from the diseased ones; these should be taken to a straw-yard or dry fold, and treated as I advised in a former part of my Essay. When any fresh cases occur amongst the healthy sheep, they should be immediately removed to those already infected; and if a fortnight or three weeks elapse without any fresh cases taking place, the healthy sheep may return to the pasture or fold they before occupied, the affected ones not being allowed to mix with them until all trace of disease has disappeared.

Ellis, who wrote in 1749, speaks of the disease being naturalized in Great Britain, and especially in counties round the metropolis. He mentions that, ewes being seized with foot-rot, it was communicated to those that were sound, and to the lambs which they suckled; and that most of the meadows were so infected with this sheep-malady that but few of the suckling ewes were ever clear from it. (Ellis's 'Shepherd's Guide,' p. 280.)

It is said, in the present day, there are pastures that will produce this disease, and that sheep cannot be placed upon them and remain free from it. Under-drain such pastures, and feed them with animals of a different class for a few months. Sell off the old flock, and in two months purchase a sound one; it will then be found that epizootic foot-rot will soon cease to exist.

Gasparin, a celebrated French veterinarian, in speaking of the

contagious nature of foot-rot, says that it occasionally spreads to the pigs, the dogs, and even poultry. I have never known an instance of the epizootic foot-rot, of which we have just been treating, to be communicated to the omnivorous, carnivorous, or to the granivorous species: probably our foreign author confounded it with the following disease.

III. *Vesicular Epizootic, or the Foot and Mouth Disease.*—This affection is highly contagious; when once produced it will spread rapidly through a whole flock, and may be communicated to animals of a different species, such as the ox, pig, and dog, and also to the fowl. It is ushered in by fever; the sheep becomes extremely lame, it walks upon its heels, there is much tenderness upon the coronet; in two or three days the hoof, round the entire foot, begins to separate, and blisters have formed at the union of the hair and hoof and between the toes. The duration of this disease, if proper remedies are applied, is from seven to fourteen days.

Treatment.—Freely purge the sheep with salts and sulphur; keep them quiet, their feet clean, and recovery will take place in about a week. Should any part of the hoof be separated, it may be removed, and the foot dressed with the vitriolic lotion, as recommended in the epizootic foot-rot.

IV. *Inflammation of the Interdigital Canal.*—Inflammation of this canal is of frequent occurrence, and is accompanied by extreme lameness; the parts between the toes, the coronet, and fetlock are much swollen, accompanied with great heat and tenderness; the sheep does not feed, and loses flesh fast. The most frequent cause of this disease is a collection of sand or gravel that insinuates itself down the canal, or it is sometimes punctured by thorns, or other sharp bodies, which will produce the same effects.

Treatment.—Wash the foot clean with soap and water; examine the canal, and remove, with a small probe or knitting-needle, any foreign body that may have lodged therein; then bandage the leg and foot with calico, moistened with equal parts of vinegar and water, and renew the dressing twice a day for three or four days. After this the parts may be smeared with common sheep-ointment twice a week, still continuing the bandage.

V. *Subcutaneous Abscess, or Whitlow.*—Abscesses occasionally form in the cellular tissue, immediately above the hoof, and produce appearances precisely similar to those of whitlow on the finger of the human subject; hence, the same designation may with propriety be adopted. This disease, so common among neat-stock, but seldom attacks sheep; however, it does sometimes occur in these animals. It commences with all the ordinary

signs of acute inflammation; there is much lameness, with heat and swelling, which extend as high as the knee; the swelling is hard just above the hoof, but softer upwards.

Causes.—It often arises from diseased condition of the blood, or is a sequel of fever; it may, however, be caused by a blow.

Treatment.—The grand object is to get matter to form as quickly as possible. Keep the sheep warm; apply a hot turnip or carrot poultice twice a day; give it also four ounces of salts. Matter having once formed, it will soon break out, and a cure will shortly be effected. If the case proves obstinate, and matter is tardy in forming, a deep incision may be made through the hardest and most pointed part of the swelling, and a bandage applied, and kept moist with vinegar and water.

In all affections of the feet in sheep, neglecting proper treatment is too often attended with one of the two formidable diseases next to be described. Inflammation attacks the soft elastic pad of the foot, and determines itself into a disease called canker; or ulceration extends into the coffin and coronary joints, affecting all parts connected therewith—ligaments, tendons, synovial membranes, cartilages, and in some cases the bones themselves. In both cases recovery is not only protracted, but so extremely rare that, unless the subject is a valuable ram or breeding ewe, the experiment of attempting a cure we scarcely consider advisable.

VI. *Canker.*—Canker is a very obstinate and destructive disease; it may invade any or all of the vascular structures, but most frequently attacks the spongy pad at the bottom of the foot; it consists in the separation of a part or the whole of the hoof, and in the formation of luxuriant and peculiar spongy sproutings, which morbid growths are secreted instead of natural hoof; there is also a discharge of white curdy matter, emitting a most offensive odour. The duration of the disease is from four to ten weeks.

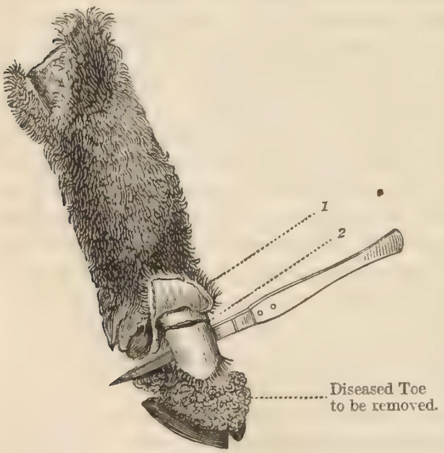
Causes.—The disease is brought on in various ways, but most commonly from neglected cases of foot-rot. It is frequently produced where many sheep are kept in confined yards, or folded upon hot dung, a plan much practised in some parts of Suffolk and Norfolk during wet seasons, when folding upon land is deemed objectionable.

Treatment.—First secure to the sheep a situation dry and clean; cut away all hoof that is separated from the sensitive parts, or, as a shepherd would say, as much as is "under-run." All separated hoof must be removed, not only in the first, but in every future dressing; the same attention must be paid to examine if any fresh under-running has occurred; then carefully wash the foot with a solution of chloride of lime, in the proportion of an ounce to a pint of water; apply then to the whole

cankered surface a pledget of tow, moistened with a lotion composed of one part nitric acid (aqua fortis) and three of water. The tow may be kept on the foot by means of a bandage, which may be continued up the leg as high as the knee, applying moderate pressure. Wash with the solution of chloride of lime, and apply the nitric acid lotion, tow, and bandage once a week whilst any unhealthy granulations remain, and new horn is forming itself.

VII. *Inflammation and Ulceration of the Coffin and Coronary Joints.*—In this disease the leg, from the knee downwards to the foot, is much swelled, tender, and painful. The sheep is very feverish, and the foot presents an entire mass of proud flesh; if the joints are perforated there is a thin purple discharge.

Treatment.—If it is resolved to spare the life of the animal by any possible means, I would recommend the affected toe to be immediately cut away; chloroform may be administered, which will not only afford immediate relief to the suffering sheep, but induce that state of quiescence so important to be preserved during the performance of such a difficult operation. Amputation of a toe may be performed in the following manner. The sheep being secured, and the hair removed, a semicircular incision may be made on the outside, as shown in diagram. After making this semicircular section, a flap will be formed (1), which must be turned up, and the bone divided with a fine sharp saw about half an inch below the fetlock-joint (see cross line in diagram, 2). The toe being then drawn down, the end of the bone will be turned out, which may be taken hold of with one hand, and the knife placed between the skin and close by the side of the bone about to be removed, the remaining attachment may, without much difficulty, be cut through. Great care is necessary to prevent the interdigital canal and joints of the remaining toe from being injured. The toe having been removed, and the digital arteries tied, the wound may be closed by stitches, a piece of lint moistened with warm water be applied to it, and the foot and leg bandaged. It is necessary to keep the foot moist for two or three days after the operation;



all future dressings must be applied according to the discretion of the operator. To keep the sheep warm and quiet for some time after the operation is indispensable.

Diseases of the Leg.

I. *Rheumatism, or the Joint-Disease.*—The affection in sheep and lambs known by the several names of the joint-disease, the joint-garget, and wood-evil, I propose to call acute rheumatism, because the symptoms during life, and the morbid appearances after death, are characteristic of no other disease.

Acute rheumatism is essentially inflammation of a particular tissue (the fibrous tissue); therefore, wherever this tissue is employed in the fabric of the body this disease may manifest itself. Inflammation may invade other tissues also; but it will be found that it has extended itself there through what is called contiguous sympathy, as in the case where the synovial membrane (which is not a fibrous membrane) becomes attacked in consequence of the rheumatismal inflammation affecting so severely the surrounding fibrous structures of the joint (the ligaments, tendons, and fibrous sheaths of the tendons). Acute rheumatism generally attacks those parts that have the greatest abundance of fibrous tissue in their composition; hence we find the large joints (the stifle, hock, and knee) the parts most frequently affected. The pericardium, or covering of the heart, is often found extensively diseased; the pericardium belongs to the class of fibrous tissues, which accounts for its diseased condition in the lamb that dies of acute rheumatism (or joint-garget).

An important peculiarity of rheumatism is its prevailing disposition to shift from one part to another: we frequently see a lamb become exceedingly lame in consequence of the existence of swelling in one of the large joints (the hock, for instance), which it suddenly quits, and attacks the hock of the opposite limb. In some cases a number of joints are affected simultaneously, sometimes only one, and the rest in quick succession; the joints of the spine, too, are occasionally stricken, while those of the extremities remain healthy. The prevalence of this joint-malady often proves most destructive to breeders, who lose great numbers of their young flock, more especially during cold and moist seasons accompanied by easterly wind. The subjects most liable to attack are the lamb, from the age of a few days to three months, and the ewe-hogget, a few days after lambing. The commencement of acute rheumatism in the lamb is marked by the animal becoming unable to follow the ewe; it appears dull, cares not to suck, and reels in its walk; twenty or thirty hours elapse, and then extreme lameness occurs; one or more of the large joints are swollen, hot, and excessively painful; the slightest

pressure or movement extorts from the little creature an expression of extreme torture. If the disease continues to affect the structures of the joints of the limbs, and the shepherd carefully attends to the patient, although it may hobble about for some weeks, it will ultimately recover. But frequently the joints of the spine are attacked when the lamb is down, and unable to rise; or the pericardium may become implicated, and then death will soon terminate its sufferings. The pericardium is generally supposed to be affected when swelling of the joints suddenly subsides, and the lamb's health rapidly declines.

Treatment.—Having so often observed cases of the rheumatic lamb, I am led to remind you of the old adage, "prevention is better than cure;" therefore I must urge upon you to attend strictly to the comforts of the young flock during inclement seasons, and place them only on lands that are well underdrained. In the way of treatment little else can be done besides keeping the patient warm, and stimulating the joints that are swollen with a liniment composed of one part spirit of turpentine, one of hartshorn, one of laudanum, and eight of linseed-oil. If the swellings about the joints continue some weeks and feel soft, an opening may be made into them, and the joint bandaged. In the case of the adult sheep I have found the following treatment remarkably successful: first, administer four ounces of linseed-oil, and twice a day for two days three grains of opium, six grains of colchicum, two of calomel, and half a pint of gruel; apply also to the joints the same liniment as recommended for the lambs: if in three weeks the joints remain swollen, strong blistering ointment may be applied to them.

Causes.—I know of no other cause of rheumatism, or the joint-disease, than cold, and especially cold combined with moisture; hence the reason why this disease usually prevails among lambs that are placed upon low undrained lands, and where proper fold regulations are wholly neglected; such, for instance, as their bedding not being well supplied with straw, the lambs not being kept in fold a sufficient time after birth, and also where they are not put into warm comfortable folds during night. Flock-masters who lamb their ewes on dry gravelly soils provide comfortable folds, and take every other precaution to prevent disease being produced by cold while the lamb is young and comparatively inactive: these breeders scarcely know what the joint-disease is; whereas those who lamb upon cold low meadows, or uplands abounding with springs, and undrained, lose annually a large proportion of their young flocks from this disease; nor will such persons abandon their unscientific and absurd notions until the superior management and repeated success of some more intelligent and skilful neighbour stimulate them at length to

adopt a system more in accordance with natural laws and the dictates of reason and experience.

Diseased appearances after death.—The sheaths of the tendons about the affected joints are much swollen, and of a dark purple hue, containing a great quantity of bloody serum, or, as a shepherd would say, of "black corruption:" this same kind of corruption is also frequently found in the cavities of the joints; the capsular ligaments appear much thickened, and their structure altered from a tough to a soft pulpy consistence. Often we find the synovial membrane completely destroyed, also the cartilages and in some cases the joint ends of bones are exposed.

II.—*Sanguineous Congestion, or Set-fast*, is characterized either by a local or general accumulation of blood upon the surface of the skin or within its texture. The texture universally implicated is the cellular tissue, within the upper part of one or more of the extremities; or the head, the viscera of the abdomen, and chest, may be respectively or collectively involved. The duration of the disease is from two to four days.

Symptoms.—The commencement of the disease is evinced by the sheep leaving its food, and becoming suddenly dull and restless; it staggers in its gait, and takes a position apart from other sheep, where it will remain some time with the head and ears drooping. In time, varying from six to twelve hours, the disease will uniformly manifest itself in one shoulder; the limb will become extremely stiff, and much pain will take place on pressure being applied between the shoulders; occasionally the hind quarters are affected, and sometimes the muscles of the entire body; the sheep at this juncture stands or lies like a block of wood.

Treatment is both simple and effectual, the sheep generally recovering in two or three days, by having administered to it a half-ounce of nitre and half a pint of linseed-oil; the same dose of nitre dissolved in a little warm water may be repeated twice a day for two days. In the case of the sheep whose whole body is hard and motionless, in addition to the previous treatment, it may be placed in hot horse-dung for a few hours (only exposing the head), which will afford marked relief.

Causes.—The removal of sheep, too early in the autumn, from white turnip and pasture feed to Swede turnips, or having too large quantities of beans and other dry grain to eat, is a frequent practice and will create the disease. Some pastures particularly seem to produce sanguineous congestion, and in this case the lamb is found to be most susceptible. I recollect, when a boy at home, in Marshland, a piece of old rich pasture, that often destroyed two-thirds of the lambs placed upon it; they did well for about six weeks after birth, and gained flesh; then suddenly

a great change would appear in them, and death quickly ensue under the following singular circumstances: the affected lamb would abruptly leave the rest of the flock, arch its back, move cautiously and stiffly, with "a straddling walk," in a few hours erect its head, stagger, fall down and die, in some cases in the short space of an hour. On examining the body afterwards there would be found adjoining the kidneys, bowels, and in some cases the lungs, a large clot of extravasated blood; the body in all other respects appearing free from disease.

III.—*Charbon, Black Quarter, or Quarter Ill.*—Charbon consists in an inflammatory pustule or boil, which, if not checked by most decisive means, rapidly terminates in mortification. The parts generally attacked are the insides of the thighs, the arms, and coronets. This affection begins with a dark-red hard swelling, in the centre of which a vesicle or blister appears, which, when opened, contains a slough or dead flesh, black as charcoal. This black matter, which is dead or mortified tissue, spreads with the greatest rapidity, involving skin, cellular tissue, and sometimes the muscles beneath.

Treatment.—The best-devised treatment is, in the majority of cases, altogether useless: however, should a trial be resolved on, only measures of the most energetic character will prove availing, as death often ensues before the shepherd is aware the sheep is ill. Immediately then, cut away all the mortified or black parts, and burn the exposed surface with an iron white hot; after this, a pledget of tow saturated with nitric acid (aqua fortis) must be placed upon the parts, and the limb bandaged; four ounces of salts and a dram of ginger may be given, and liquor ammoniæ acetatis two drams; also of nitric ether two drams three times a day. In two or three days remove the dressing, cut away, and apply the hot iron to any new slough, and continue the acid and bandage, repeating the dressing until healthy and red flesh appears. Nursing, in addition to warmth, must be duly attended to.

Causes.—These are of two kinds: 1st. General infection of the system, from respiring air loaded with miasmata, or infectious and morbific effluvia, which are frequently evolved from low marshy undrained lands, or from diseased animals: 2nd. By inoculation of the diseased fluids; hence, it is of the first importance that a diseased subject should be immediately removed and kept apart from healthy sheep or other animals. Persons who handle them must be very careful to prevent any of the diseased parts from coming in contact with an abraded portion of their skin, and must be careful on no account to inhale long the vapour which emanates from the carcase. This disease has frequently been produced by flies that have alighted

on the ulcers of dead animals, and, thence conveying the virus, infect other animals and human beings. Mr. Lawrence gives an account of a man in Leadenhall-market who accidentally smeared his face with some stinking hides from South America; the part touched by the putrid matter very soon became red, swelled, and mortified, and the mortification spread over half the cheek.

IV.—*Strains.*—The sheep not being an animal of burden, neither used to carry nor draw weight, strains are consequently of rare occurrence; however, they do occasionally happen and produce lameness; it is therefore necessary to notice them. The fetlock, hock, and stifle are parts most subject to such injuries.

Treatment.—Should the flock be under the management of a careless fellow, fond of mercilessly hunting his sheep over hard and rough fields with improperly trained dogs (a practice never adopted by discreet shepherds), the crippled patient must be removed from the rest of the flock, and have applied to the parts affected, every other day, a liniment composed of one part hartshorn and six of linseed-oil.

V.—*Fractures.*—The limbs of sheep are frequently fractured; the leg, thigh, and arm bones most commonly meet with the accident. Merely to reduce a fracture in an animal is a simple operation; but to keep the ends of a fractured bone in juxta-position by splintering and bandaging requires considerable tact and patience, as the proper union in many cases is not speedily attained. Bones deeply imbedded in flesh, such as the upper thigh and shoulder, do not require any surgical treatment; these bones will re-unite if the sheep is only kept quiet a few weeks. A fractured leg or thigh should be treated as follows: provide three gutta-percha splints, one-eighth of an inch thick, eight inches long, and one inch wide; a roll of calico bandage an inch and a half wide and about four feet long (more or less as the case may require); cover the limb with boiled starch, soften the gutta-percha splints in hot water, and lay them across the fracture; then bandage the leg moderately tight. If the starch is not sufficiently adhesive to hold the bandage in its place, a mixture of four parts (by weight) common tar and one of gutta-percha, melted together and applied warm to the leg, may be substituted. Recovery will generally take place without further trouble.

The cultivation of the ovine species having promoted in an eminent degree the commercial prosperity and domestic comfort of Great Britain, the author with satisfaction contributes the remedies which in his experience appear best cultivated to render these valuable animals less liable to the inroads of disease or accident, and he cannot close this Essay satisfactorily without respectfully suggesting to the members of the Royal Agricultural

Society his conviction of the propriety and importance of *educating* shepherds in such a manner that they may be qualified to discharge the momentous duties which frequently devolve upon them with promptitude, judgment, and skill.

II.—*Hereditary Diseases of Sheep and Pigs.* By FINLAY DUN, Lecturer on Materia Medica and Dietetics at the Edinburgh Veterinary College, and Author of 'Veterinary Medicines: their Actions and Uses.'

BRITISH agriculturists are daily becoming more and more impressed with the truth of the familiar saying that "prevention is better than cure." They are accordingly employing more skill, science, and capital than heretofore, in the management of all the domesticated animals, and in the improvement of their sanitary condition, by providing them with abundance of suitable food, with sheltered pasturages, and with clean, well-ventilated, and comfortable abodes, and by protecting them from the ordinary causes of disease. But there are other subjects upon which the scientific and practical experience of breeders and proprietors of stock should be brought to bear, and amongst these we may adduce one which has as yet met with too little attention—the detection and removal of those hereditary defects and diseases by which so much loss and disappointment are occasioned to the proprietor of live stock.

It is the consideration of such diseases among sheep and pigs which forms the subject of the present Report; and in order to avoid confusion and unnecessary repetition, we shall discuss it under these three heads:—

I. General considerations regarding hereditary defects and diseases.
II. Hereditary defects and diseases of sheep.
III. Hereditary defects and diseases of pigs.

I. There is ample evidence of the hereditary nature of certain defects and diseases among the lower animals, as well as among men. The progeny of parents affected by various diseases are more prone to these diseases, and are affected by them in larger proportion, than the progeny of parents in whom such diseases have never shown themselves. This is exemplified in consumption, scrofula, and epilepsy. But the hereditary nature of disease is merely a single illustration of a very general and important natural law, embodied in the axiom, "like produces like," and applying to all the characters and qualities of living beings,

physical and mental, healthy and diseased. In obedience to this natural law the grain of wheat, when placed in the soil, shoots up its grassy stem, and bears numerous grains resembling the parent seed. The seed which falls from the forest tree produces a tree like that which yielded it, and every flower and herb reproduces its own kind and no other. Throughout the animal kingdom the same law also regulates the transmission from the parent to the offspring of salient qualities, whether good or bad, external or internal. But to examine somewhat more fully these interesting topics, and to illustrate more satisfactorily the subject of this Report, we shall notice briefly some of the more important hereditary qualities of sheep and pigs.

The numerous varieties of the human race, as well as of every species of the lower animals, are doubtless due to the modifying influence of external circumstances, and the perpetuation of acquired distinctive peculiarities. We must therefore attribute the existence of the many varieties of sheep which are found in the world, to the hereditary transmission of distinctions originally, either mere *lusus naturæ*, or the ordinary modifications induced by climate and other external circumstances. Our English Leicester and Southdown, our Scotch black-face, the Argali of Siberian Kamschatka, the fat-tailed sheep of Syria and Barbary—in short, all the existing varieties of sheep, however distinctive their present characteristics, have had one common origin, and have become distinct breeds only by the hereditary transmission of acquired peculiarities. Of course to form varieties differing so widely in external form and in habits, has required the lapse of thousands of years; but in illustration of the principle, and as an instance of the transmission of acquired characteristics, forming a distinct variety in a comparatively short time, we may adduce the breed of sheep now found in Massachusetts, distinguished by an otter-like form, long body and short and crooked legs. This breed had its origin in 1791 with a male lamb born with these peculiarities, which, although at first merely accidental, have, by continual care and cautious breeding, been rendered permanently hereditary. The variety is highly prized on account of its being easily kept within fences.*

But it is not the distinctive characteristics of different breeds that are alone transmitted from parent to offspring. Different families of the same breed are often characterised by hereditary distinctions, such as peculiar colours and markings; indeed almost every sheep-owner must be able to recollect instances of particular families distinguished for many generations by the frequent appearance of individuals with black fleeces, black legs

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* Youatt on Sheep, p. 135.

and feet, or even black spots on the same parts of the body. Grey legs and faces are the hereditary markings of many families of pure Leicester sheep. Ælian, a Latin author of the date B.C. 320, mentions that the sheep on the banks of the river Xanthus were remarkable for their yellow fleeces;* and Dr. Buchanan, while journeying through Mysore, remarked that in that country there were red, black, and white sheep;† and in all these cases the particular colour of the parents reappeared in the offspring, so long as the different families remained unmixed. The existence or non-existence of horns, their length and configuration when present, the quantity and quality of the wool, and many other peculiarities of different families and varieties of sheep, are all decidedly hereditary. Besides these physical qualities there can be no doubt of the dispositions and habits of sheep being also hereditary, although in this respect we have not the same opportunities of judging as in horses or dogs.

Among pigs may also be discovered numerous illustrations of the law of hereditary transmission quite as striking as among sheep. Length of limb, form of carcase, size and form of head, erect or pendulous ear, early maturity, and fattening capabilities, are all reproduced in the offspring. Many families are remarkable during many generations for peculiar colours and markings. Throughout most parts of America the wild hogs are quite black, but at Melgara and some other places they have a white band running along the belly and extending over the back; while in some of the warmer parts of the New World they are red.‡ Blumenbach mentions that the swine of Piedmont are black, those of Normandy white, those of Bavaria reddish brown, and also that all those seen by him at a large fair at Salenche were black. In our own country too these peculiar colours and markings often continue through many generations the hereditary insignia of certain families of swine. In many parts of Asia, and wherever the climate is fine and mild, the skin is delicate and almost bare, or only thinly covered with a few soft hairs; but in cold, exposed, and mountainous regions it is plentifully covered with thick fur, beneath which is often found a sort of wool. These differences, though originally depending on the modifying influence of external circumstances, have become permanent and hereditary, and continue to be produced for several generations, even when the animals are placed under entirely different circumstances. In Hungary, Sweden, and some parts of England, swine are found with solid hoofs; in the island of

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* Researches into the Physical History of Mankind, by James Prichard, M.D. 1826. Vol. I., p. 194.

† Op. cit., p. 195.

‡ Natural History of Man, by James Prichard, M.D., p. 29.

Cubagua with toes half a span in length, and in many other parts of the world with the hoof divided into four digits. The celebrated naturalist, Buffon, says that pigs in Guinea "have very long ears, couched upon the back; in China a large pendent belly and very short legs; at Cape Verd and other places very large tusks, crooked like the horns of oxen; in domestication half pendent and white ears."* Now all these characters are decidedly hereditary, and though, as above mentioned, some of them may, in the first instance, have been gradually induced by the continued operation of external circumstances, still they have become fixed and permanent, and can only be altered or removed by crossing for several successive generations with animals possessing different or opposite characters, or by the modifying influences produced by change of climate, &c.

The hereditary transmission of defects and diseases is often less obvious than that of form, size, and colour; for there is sometimes no very apparent peculiarity of structure or general appearance in animals well known to possess a decided tendency to disease. But such a tendency, though sometimes invisible, and even inappreciable to ordinary powers of observation, must still, judging from its effects, have as certain and definite an existence as any external peculiarity of form. Every one who believes that a disease may be hereditary at all must admit that certain individuals possess certain peculiarities which render them unusually liable to certain diseases, as scrofula, consumption, and dysentery; yet no one can say precisely in what this special predisposition consists. We believe that in each case it consists in some faulty formation, some want of harmony between different parts and organs of the body, or some peculiar physical or chemical condition of the blood or soft solids; and that this altered state, constituting the inherent congenital tendency to the disease, is duly transmitted from parent to offspring, like any of the corporeal qualities above referred to.

From what has just been stated, it will be evident that it is not usually the disease, but only the tendency or predisposition to it, which is hereditary. Few individuals are born with any particular disease already developed, but many with a predisposition to disease. Such a predisposition may vary much in degree and intensity. It may be so strong that no care or skill can prevent the development of disease, or so slight that it does not interfere with the health or usefulness of the animal, or cause actual disease, unless with the co-operation of active exciting causes. Thus, a predisposition to consumption is the ill-fated inheritance

* Natural History of Man, by James Prichard, M.D., p. 32.

of many families both of sheep and pigs. But in some individuals of such families the tendency to the disease may remain altogether latent; while in others it may either naturally or from untoward circumstances be so much more intense that a slight exposure to any of the ordinary exciting causes of consumption will determine at once the production of the disease.

But it may be naturally inquired *how* are certain qualities of body and mind transmitted from one generation to another? or, in other words, *why* do the progeny resemble their parents in form, temper, and liability to particular diseases? To afford any satisfactory explanation of this we must look to the process of generation. The production of the embryo is determined by the action of the male semen on the female ovum: but the semen is only a secretion of the male parent, endowed with its vitality, and probably impressed with its characters. The ovum probably contains in miniature the constitutional peculiarities of the female parent; and the embryo resulting from the congress of these two is therefore a fusion, as it were, of certain vital parts derived from each parent, concentrating certain individualities of each, and endowed, we may suppose, with a part of the vital force of each. We may further believe that this vital force continues to regulate and control the nutrition and growth of the embryo throughout all stages of its development, and so renders it similar to the parentage from which that vital force was originally derived.

But each parent impresses on the fœtus not only its own habitual, material, and dynamic state, but also those more temporary and more accidental qualities which it may possess at the time of sexual congress. Children begotten by parents while in a state of drunkenness frequently become idiotic or insane. Burton, in his 'Anatomy of Melancholy,' says, "if a drunken man get a child, it will never likely have a good brain;" and Diogenes is said to have remarked to a crack-brained, half-witted stripling, "Surely thy father begot thee when he was drunken." A child, begotten shortly after the father has had a severe injury of the head, has sometimes turned out of weak intellect; and an apt illustration of this is recorded by George Combe.* "A man's first child was of sound mind; afterwards he had a fall from his horse, by which his head was much injured: his next two children proved to be both idiots. After this he was trepanned, and had other children, and they turned out to be of sound mind." The Arabs and other Asiatic nations appear well aware that those qualities which are most prominent in the parents at the time of sexual intercourse are reproduced in the offspring; and, accordingly, in the breeding of horses, they give

* Combe's Constitution of Man. Fourth Edit. Pp. 44, 45.

the stallion and mare a smart gallop before they bring them together. The endurance, strength, and spirit of both animals are thus more highly developed, and are believed to be transmitted to the offspring in this intensified state. The excitement of the gallop doubtless alters in some degree the conditions of the semen and ovum, and when the latter is fertilised the altered conditions still remain, and go on growing and strengthening throughout fœtal life. The male offspring also have usually a special resemblance to the father, and the female to the mother; and the resemblance is not confined to external form or mental attributes, but extends to defects and predispositions to disease. This is admirably illustrated by the propagation in the human subject of consumption and insanity which, in the majority of males, is inherited from the father, and in the majority of females from the mother. The proportions are exhibited in the following Tables: *—

Consumptive Males	106	Consumptive Females ..	108
Consumptive Fathers ..	63 or 59·4 per ct.	Consumptive Fathers ..	47 or 43·5 per ct.
Consumptive Mothers ..	43 or 46·6 per ct.	Consumptive Mothers ..	61 or 56·5 per ct.
Insane Males	117	Insane Females	147
Insane Fathers	64 or 54·6 per ct.	Insane Fathers	67 or 45·4 per ct.
Insane Mothers	53 or 45·3 per ct.	Insane Mothers	80 or 54·4 per ct.

Among the lower animals the statistics of disease are as yet very meagre and imperfect, but we have sufficient evidence to prove that in them, as well as in the human subject, diseases are especially prone to descend from sire to son, and from dam to daughter. This may possibly be so far explained by the fact that the male offspring, as above remarked, usually resemble the sire, and the female the dam; and whenever an animal especially resembles one of its parents in external and healthy characters, it is almost certain also to resemble it in those which are internal and morbid. *See* ADDENDUM, page 42.

In order to prevent or remove hereditary defects and diseases, great care must of course be exercised in the selection of both parents, so as to obtain them with as many good qualities as possible, with a strong and vigorous constitution, and freedom from those faults which are likely to interfere with usefulness and health. Care must especially be taken to avoid, for breeding purposes, all animals affected with any constitutional diseases, or *blood-diseases*, as they are sometimes called—such as scrofula,

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* Lugol on Scrofula, and Philips on Insanity.

consumption, or rheumatism; as also all those affected by any disease depending upon structural change of any part or tissue. Accidental and acquired diseases or deformities are less apt to be propagated than those which are congenital or inherent; but, like external peculiarities, they do sometimes become permanently hereditary, and hence it is usually safer and wiser also to discard animals so affected.

When it is desired to breed from any animal which, though recommending itself by superior general qualities, has nevertheless some slight defect of symmetry, or some faint tendency to disease (for which, however, scarcely any good qualities can, we think, sufficiently compensate), it should be mated with an animal which is super-excellent in every respect in which it is deficient. On no account should any animal of doubtful perfection, or suspected soundness, be allowed to breed with one near of kin to it; for in the great majority of such cases both parents will have similar imperfections and faults, which will appear in the offspring in a far more prominent and aggravated form than they existed in either parent.

The rearing and general management of animals having a hereditary tendency to disease also requires unusual care; for such animals are very apt to suffer from all influences inimical to health. In them ordinary causes of disease operate speedily and powerfully: common and simple disorders are apt to urge on the hereditary predisposition to actual disease, and afterwards to become themselves absorbed into the malady they have produced; while remedial measures act only imperfectly and palliatively, for they cannot of course remove the morbific tendency—the *fons et origo* of the malady. Such tendencies can only be effectually eradicated by crossing not only the animal itself, but also its offspring for several generations with perfect and healthy stock. Nor must the breeder be misled by the disappearance of any defect or disease during a *single* generation, for a tendency to disease often remains latent for one or even two generations, and then reappears with all its pristine force. This is often illustrated by consumption, epilepsy, and indeed by all hereditary diseases, and also by hereditary peculiarities of shape, or colour, which, like diseases, often skip over one or two generations, and then reappear. This phenomenon is technically called *stadism*, and the offspring are said, in the language of many breeders, to *call back* to their grand parents or other more remote ancestors.

In order to maintain stock, whether horses, cattle, sheep, or pigs, in perfect symmetry and free from all defects and diseases, it is absolutely necessary to prevent the females from being put to any male having qualities that are to be avoided, for the

immediate produce of such a cross is not only defective itself, but all the future progeny of the same female is apt to be defective likewise, and to partake of the characteristics of the faulty male, especially if he be the one with which she has first had fruitful intercourse. Numerous examples, both among the human species and among the lower animals, might be given to illustrate this curious fact. Women married for the second time frequently have children which bear a striking resemblance to the first husband, both in physical and mental development, as well as in defects and diseases; for, as has been already remarked, resemblance in anatomical and physiological characters is ever accompanied by resemblance in pathological characters. Every one is familiar with the well-known case of Lord Morton's chestnut mare of pure Arab breed, which had a foal by a quagga, or wild ass, and whose subsequent foals by Arabian and thorough-bred horses still resembled the quagga foal in the peculiar stripes along the head and back and in the stiff, straight, upright mane.* Delabère Blaine mentions several illustrative cases occurring among dogs,† and also a case of a black and white sow, which had pigs to a wild boar of a deep chestnut colour, and had afterwards, by different boars of the Essex breed, several litters which resembled the progeny of the wild boar in colour and general appearance. These facts have been variously accounted for. 1st. A permanent influence is believed to be exercised on all the ova of the female by the semen of the first male — an opinion entertained by Haller and several other eminent physiologists. 2nd. The first fœtus, possessing of course the prominent characters of the first male, is believed to produce a kind of inoculation of the female. The blood of the fœtus passes by the placental circulation into the blood of the mother, and there produces changes of a more or less permanent kind, which are propagated, along with her own proper characters, to each subsequent progeny, whether by the same or by different males. This view has recently been ably propounded by Dr. Alexander Harvey,‡ and appears to afford very satisfactory explanation of the cases above mentioned. 3rd. The resemblance which the offspring of the same mother by different males often has to the offspring of the male with which she first had fruitful intercourse has been supposed to depend on the imagination of the female, and her continued recollection of her first mate and her first offspring. This, though a very

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* Rural Cyclopædia. Blaine's Veterinary Art, p. 244.

† Blaine's Canine Pathology. Fourth Edition, pp. 46, 47.

‡ Edinburgh Monthly Medical Journal for October, 1849, and for October and November, 1850; and his pamphlet 'On a remarkable Effect of Cross-breeding.' Edin. 1851.

pretty poetic fancy, is inadequate to explain satisfactorily such cases as the above. It must not, however, be inferred from this remark that the imagination has no power in affecting fœtal development. On the contrary, it can be easily shown that mere sensuous impressions acting on the female at the time of impregnation, or even during pregnancy, are sometimes capable of affecting the offspring. Mares and bitches frequently produce offspring differing from the sire, but resembling in colour and appearance those animals with which the mother has been kept, or of which she has been fond. George Combe mentions a case in which two horses were got with pretty markings of a very uncommon kind, by leading a horse having such markings before two mares just prior to their being covered. The parents in each case were different, but the young horses were so similar in colour that they could scarcely be distinguished from each other, and both had the same markings as the horse that was led before the mares at the time they were impregnated.* Similar illustrations of the influence of the imagination are common among dogs; and Mr. Milne has recorded, in the Transactions of the Linnæan Society, the case of a pregnant cat, which got a severe injury of the tail from a tread, and gave birth shortly after to five kittens which were perfect in all respects except that "the tail was distorted near the end and enlarged into a cartilaginous knob."† In the human subject, idiotcy, peculiarities of physical development, and physical deformities have been traced to mental impressions made on the pregnant mother.‡ It is evident, however, that, among the lower animals, the imagination is less powerful and excitable, and less capable of extended action, than in the human subject; and we may therefore believe that it does not, in the majority of cases, affect fœtal development, except by occasionally causing but slight alteration in colour or external form.

II. *Hereditary Defects and Diseases of Sheep.*—The hereditary diseases of sheep have as yet been but little studied, probably on account of these animals being usually considered scarcely worthy of medical treatment, and of their being slaughtered at a comparatively early age, and before much time has been allowed for the development of many diseases. But from what little information we have on this subject, there is no doubt that when any of the diseases, which are hereditary among men or the lower animals, occur in sheep, they will in them likewise prove hereditary. Diseases of this nature are often engrafted on previously healthy stock by neglect and mismanagement; for although at first accidental and acquired, they are almost certain to become

* Combe's Constitution of Man. Fourth Edition, p. 104.
† Blaine's Canine Pathology. Fourth Edition, p. 48.
‡ Whitehead on Hereditary Diseases, pp. 14–20.

after a few generations fixed and permanent and almost incapable of being eradicated. In noticing the more important hereditary diseases of sheep, we shall endeavour to indicate, as fully as our limited space will permit, the nature and symptoms of these diseases, and also, so far as is known, the external and visible signs which indicate a predisposition to them. Such signs should especially be noted by breeders, as enabling them to detect defects and predispositions to disease which otherwise could be discovered only by a knowledge of the animal's pedigree.

In discussing this head we shall adopt the following arrangement:—Diseases of the brain and nervous system; diseases of the thoracic and abdominal viscera; rheumatic and scrofulous affections; and general faults and vices of external form.

There are several diseases of the brain and nervous system which are decidedly hereditary in all animals. Amongst the more highly improved breeds of sheep, many individuals, usually distinguished by their square and compact forms and soft pliant skins, are able to manufacture in a short time large quantities of blood. In favourable circumstances they carry on this process more rapidly than the wants of the system require, and thus get speedily into high condition. But this valuable tendency to assimilate food readily, and to grow and fatten with rapidity, often becomes a predisposing cause of disease. So long as the various processes of secretion and excretion go on regularly, all is well; but if any of these be materially deranged—if, for example, constipation occur—an abnormally large amount of highly stimulating blood will remain circulating in the body without adequate ways or means of removal, and will be driven in a full and rapid current to every part, producing inflammation in any organ which may be predisposed to it by natural or acquired causes. Should no such predisposition obstruct its onward flow, the vessels in some part may give way. Thus arise various kinds of *hæmorrhage*, and in no organ are these more common or more to be dreaded than in the brain, where the blood-vessels are large, numerous, delicate, and but feebly supported by the soft cerebral mass in which they lie. From rupture or excessive distension these vessels sometimes allow of the pouring out of blood or of the serum of the blood, constituting the usual form of the disease generally known as *apoplexy*. The most common symptoms of this affection are sudden loss of perception and power of motion, and gradually increasing coma, which destroys life more or less suddenly. In predisposed subjects such apoplectic attacks are often induced by sudden changes from poor to rich pastures, by long and fatiguing journeys during hot weather, or by any causes which give rise to

constipation. When a decided tendency to apoplexy shows itself, means should be taken to prevent the manufacture of an undue amount of blood, by giving unstimulating and not over-nutritive food in moderate quantity. The constant activity of secretion and excretion should also be secured by free ventilation and cleanliness; by affording the animal access to good pure water, and if necessary by the occasional exhibition of laxatives. Such measures will be much safer and more effectual than the copious blood-lettings and purgings which are often recommended in such cases, and which, though they may prevent the disease for the time, frequently do more harm than good, since without due attention to diet they increase the disposition to the excessive manufacture of blood.

Epilepsy or *fits*, as it is often significantly termed, occasionally occurs among sheep. The animal attacked becomes suddenly stupid, gazes vacantly about him, and falls down struggling and senseless. His muscles are thrown into violent and general spasms, his eyes start from their sockets and are often distorted, his jaws are forcibly closed, his tongue is protruded, and his fæces and urine are passed involuntarily from the violent spasmodic action. His respiration is irregular and gasping, and his circulation usually much disturbed by venous congestions. The convulsions vary much in severity and duration, usually lasting only a few minutes, but recurring repeatedly at very short intervals. Epilepsy occurs most commonly in young sheep in good condition, but also occasionally in lambs about weaning time. It may attack any kind of sheep, but is especially frequent among those that are delicately bred and of a scrofulous constitution. It is sometimes very violent, and occurs frequently without proving fatal; but its prognosis depends entirely upon its nature and cause. Thus, when depending on any local irritation of the intestines, or, in other words, if it is merely sympathetic or eccentric, it is usually tolerably easy of cure, is not likely to return after its cause has been removed, and is not usually hereditary; but when it depends on some morbid condition of the brain or nervous system, and occurs in animals of a scrofulous disposition, it is almost incurable; is apt to occur again and again, until death puts a period to its attacks, and is almost always hereditary. It is distinguished from apoplexy by the absence of coma, and from tetanus by the intermissions of the spasms, and by the fact that it usually attacks one side or one half of the body more seriously than the other. The precise nature of the disease is not well known: the functions of the brain appear to be disturbed or altogether held in abeyance, and the rest of the nervous system—thus released from the regulating and controlling influence of its central director—acts in an irregular, and often

violent, manner; but the nature of those changes, which doubtless occur within the cranium, still remains unexplained, and in this instance *post mortem* examinations do not help us much. There is usually more or less softening of the brain; but sometimes neither the brain nor any part of the nervous system presents anything abnormal. The vascularity of the brain, and its engorgement with dark-coloured blood, so much spoken of by some authors, depend chiefly on the blood being driven in undue amount to the deep-seated organs by the violent contractions of the external muscles. But apart from the nervous system, there are often found derangements of other organs, which seem frequently connected with the production of the disease. Thus, among both sheep and cattle, the third stomach is usually filled with hard, dry, and partially-digested food; in dogs, the small intestines are frequently filled with worms; and in these and other animals the lungs and other parts are sometimes studded with tubercles. But we know little, if anything, of the manner in which these conditions produce epilepsy, nor indeed of the *modus operandi* of plethora, derangements of the digestive organs, exposure to cold, or any of the other causes of the disease. These appear sometimes adequate to produce the disease among stock of untainted pedigree, but always act most certainly and powerfully among those inheriting a predisposition to the disease. The existence in certain individuals of an inherent predisposition to epilepsy, and the transmission of such a predisposition from parent to offspring, appear undoubted. The disease is always especially frequent and formidable in the progeny of those sheep that have themselves been subject to it. One extensive agriculturist informs us that he at one time had it frequently among his flock; that it descended for "several" generations; but that since he sold off the faulty race, and drained and otherwise improved his farm, he has seen none of it. Most breeders and shepherds, though they speak most decidedly of the hereditary nature of the complaint, are unable to give much statistical information regarding it. The hereditary nature of epilepsy when it affects the human species, is now well ascertained. MM. Bouchet and Casavielh found that of 110 cases of epilepsy, 31 were hereditary; and Esquirol found that of 321 persons afflicted with epileptic insanity, 105 were descended from insane and epileptic parents.* A hereditary tendency to epilepsy cannot, among sheep, be distinguished by any external appearances. Those prone to it are said to have large, unshapely, unsymmetrical heads, with one-half unlike the other; but such characters, though indicating a tendency to epilepsy in man, are

* Watson's Principles and Practice of Physic. Third Edition, vol. i. p. 637.

of less value among sheep, for in the case of the latter animals they are sometimes present where there is no tendency to the disease, and sometimes absent where the tendency is undoubted.

Sturdy, *turnsick*, or hydatids in the brain, used to be very prevalent in this country, but is now chiefly confined to localities as yet unreached by modern improvements in agriculture and reforms in the management of stock. It is rarely met with where the land is dry, and the flocks well tended and fed. Youatt * and other writers seem to view it as directly hereditary; but this is very improbable, and is not borne out by careful observation. Sheep affected by the disease do not produce lambs exhibiting any unusual proclivity to it; but as it most frequently affects animals of a weak and depraved state of body, and as such states of body are notoriously hereditary, the disease may rather be considered as hereditary from indirect causes.

Chronic diseases of the respiratory organs are generally accompanied by some alteration of structure which has assumed a hereditary character. This is often the case with the irritable condition of the bronchial mucous membrane, which gives rise to *chronic cough.* This affection is of frequent occurrence among sheep, is attended with so much irritation as sometimes to prevent the animal from thriving, and occasionally leads to inflammation of the lungs. It is always much aggravated during wet or changeable weather. Sheep with narrow throats and chests, and of a consumptive constitution, are most commonly predisposed to chronic cough. We might here consider pulmonary consumption as one of the hereditary diseases of the respiratory organs, but shall postpone its notice until we come to speak of scrofulous complaints.

Some of the *diseases of the digestive organs* of sheep are apt to owe their production in part to the action of hereditary causes. This is particularly the case with diarrhœa and dysentery, which are especially frequent and severe among animals of a spare lank form, with flat ribs, much space between the prominence of the haunch-bone and the last rib, angular quarters, and badly set-on tail; dark, scurfy-looking skins, and soft, flabby, muscular systems. In such sheep the intestines are weak, and apt to suffer even from the slightest disturbing causes. Exposure to wet or cold, or sudden alterations of food, speedily determine a troublesome *diarrhœa*. This is especially apt to occur during spring and autumn, particularly in lambs, amongst which it frequently causes considerable mortality. We are apt to entertain very vague ideas concerning this common and simple complaint: it is usually produced by some irritant matter either introduced into

* Youatt on Sheep (Library of Useful Knowledge), pp. 381, 382.

the blood from without, as in the food, or accumulated there from the imperfect action of such organs as the skin or kidneys. Nature separates these irritant matters from the blood by the intestinal mucous membrane with its glandular apparatus, which becomes stimulated to increased activity and augmented secretion by the local action of the irritant. The complaint is sometimes caused by the lodgment in the intestines of acrid, indigestible food, which induces a local irritant action, and a consequent increase in the movements and secretions of the canal. It is also occasionally caused or kept up by an undue amount of fluid being poured into the canal from the relaxed intestinal vessels. Diarrhœa in healthy stock, and when early attended to, may usually be speedily arrested by a change of pasture, dry food, and sufficient shelter; but when it occurs in animals with weak intestines or a vitiated constitution, and especially if it have been allowed to go on neglected, it is very apt to be the precursor of *dysentery*. This last disease sometimes continues for many months, sometimes only for a few weeks. The animal first falls off in condition; he appears "to do no good," to use a familiar but expressive phrase. His thirst is excessive, his appetite irregular and capricious, and his rumination imperfect. The wool is dry and hard, and the skin covered with a dingy yellow scurf; the fæces are evacuated forcibly, with straining and pain, and contain imperfectly-digested portions of the food, with dark-coloured mucus and blood; the back is arched and the belly tucked up; the pulse is weak, soft, and compressible, and seldom above seventy. Respiration is somewhat accelerated, and a cough is generally induced by tubercles in the lungs or liver. The sheep occasionally kicks at its belly as if suffering pain; serous effusions appear underneath the jaws, at the brisket, and in the limbs, and other dependent parts—sure indications of impoverished and vitiated blood; the breath and all the secretions become fœtid, the strength fails, and the animal, worn to a skeleton, dies from utter exhaustion. With such decided symptoms as these, indicating in the most striking manner the nature of the disease, it is strange that any one would gravely propose to treat it by bloodletting; yet Mr. Youatt and others have recommended bleeding and several doses of physic, for the purpose (say they) of overcoming the inflammation and fever.* But the inflammation of dysentery is of a sub-acute and vitiated kind, and is hence greatly aggravated by the abstraction of blood; and the fever is of a low typhoid type, requiring tonics and stimulants rather than antiphlogistics. We merely advert to this error as indicating the essential importance of understanding

* Youatt on Sheep, p. 470.

the pathology of a disease before undertaking its treatment. On dissecting the body of an animal that has had an attack of dysentery, the stomachs are usually found quite sound and healthy except the fourth, which is of a light colour, and exhibits extravasation of blood between its coats. The small intestines have a similar appearance, but are not generally ulcerated; the coats of the large intestines are puckered from chronic inflammation and contain ulcers of various sizes. In some parts the mucous membrane is entirely destroyed, and its place occupied by proud flesh. These changes appear to depend not so much on inflammation as on an impoverished condition of blood and an imperfect nutrition of the parts. As the mucous membranes require for their healthy nutrition a great amount of blood, they suffer from the impoverishment or vitiation sooner than most of the other tissues. This is illustrated in glanders in the horse, as well as in the disease under notice. The liver, lungs, and mesenteric glands contain tubercles, and occasionally pus, and this is one of the many evidences of the close relation betwixt dysentery and pulmonary consumption. This relation is further borne out by the fact that both occur in the same kind of stock, are substituted the one for the other in different individuals of the same family, often occur at different times in the same individual, and frequently merge into each other. They are also both hereditary, and originate from similar causes, and from none more often than from breeding in-and-in, that is, breeding from animals near of kin. This system, when judiciously practised, causes early maturity and a disposition to grow and fatten speedily; but when followed injudiciously and persisted in for several generations, it invariably does much injury, diminishing the size and vigour of the flock, rendering the male animals weak and incapable of procreating their kind, and the females barren or unusually liable to abortion, engendering a disposition to dysentery, scrofula, and other malignant diseases, and greatly aggravating any previous hereditary tendencies.

Rheumatism is a peculiar inflammation of serous, fibrous, and fibro-serous tissues, and has the strange disposition to flit about from one part to another, now involving some of the larger joints, now some of the sheathing envelopes of muscles or tendons, and again, as in most fatal cases, the fibro-serous membrane investing the heart. In its acute forms it is accompanied by active inflammatory fever, a full, strong, and rapid pulse, and arrestment, more or less complete, of all secretion and excretion. In sheep it often affects the fibrous coverings of the muscles of the neck and back, causing stiffness along with the various symptoms just noticed. It is very apt, particularly in its more chronic form, to attack the synovial and cartilaginous tissues of the joints, causing

much pain, swelling, and lameness. It attacks animals of all ages; but lambs, from their inability to withstand intense cold, are generally most severely affected. Among sheep the disease usually owes its production in great part to the operation of external or exoteric causes, as being exposed to cold and rain, or lying on damp, undrained ground. Indeed, whenever rheumatism occurs, it is a certain evidence of the want either of effectual shelter or of sufficient drainage. But these exciting causes often receive most active co-operation from congenital predisposing causes. The nature of such congenital causes is unknown, but their existence is often indisputable. It is well ascertained that when rheumatism has once occurred it is very apt to occur again, owing, we believe, to some peculiar alteration of tissue induced by the first attack. Now, it is, we think, some such altered condition of tissue, transmitted from one generation to another, which constitutes a hereditary tendency to the disease. Indeed, in the human subject, as well as in cattle, rheumatism is now generally admitted to be hereditary; and since in sheep the disease is in every other respect the same, we are surely justified in pronouncing it to be hereditary in them likewise. Care must therefore be taken to avoid for breeding purposes all sheep that have been subject to rheumatism, and also those with lank ungainly forms, long unsymmetrical limbs, large coarse joints, and other marked indications of predisposition to the disease.

Scrofula frequently occurs among sheep, presenting itself under several different forms, and predisposing to a great many diseases. In sheep of a strumous or scrofulous constitution or habit of body, the blood is not properly elaborated, and contains an excess of albumen, with a deficiency of red corpuscles and fat, and forms a loose and soft coagulum. During ordinary nutrition, but more particularly during inflammation, it is apt to deposit, especially on free mucous surfaces, a peculiar non-organisable matter termed tubercle—a substance of a yellowish white, opaque, granular, often cheesy appearance, and consisting of variable proportions of albumen, a little fatty matter, and salts chiefly of lime. Wherever the most minute speck of such tubercular matter is precipitated from the blood, it is very apt to increase in size by continual accretion. The form of the deposit is moulded by the interstices of tissues with which it is in contact; but, when not pressed on, its form is undeterminate. It is not subject to any vital changes, and is incapable of organisation, but often becomes, after a time, hard and gritty, from the removal of its more fluid and organic parts. In contact with vascular tissues, it is very apt to induce much irritation and inflammation, accompanied by unhealthy effusion and the

deposition of more tubercular matter. These deposits occur in almost all the tissues of the body:—in the brain or on its membranes, causing disturbance of the cerebral functions; in the mesenteric glands, causing derangements of digestion and assimilation; on the intestinal mucous membrane, frequently inducing diarrhœa and dysentery; and still more commonly in the lungs, giving rise to difficulty of breathing, languishing, and all the well-known symptoms of pulmonary consumption.

In all animals the scrofulous constitution is decidedly hereditary, and among sheep we have repeatedly seen it transmitted from parent to offspring for three or four generations. The precise condition which in such cases is transmitted is unknown. It may consist in some alteration in the quality of the blood, or the proportion of its constituents, or, more probably, in some abnormal state of the soft solids. But in whatsoever this condition may consist, it is almost always accompanied by certain external appearances, which enable us to distinguish with tolerable certainty those sheep in which scrofulous diseases are especially apt to develop themselves. They have thin, small necks, narrow chests, pot bellies, thin and delicate skins, fine wool sparingly spread over the head, legs, and belly, tender eyes, weak circulation, small bones, soft flabby muscles, and a general disproportion among the different parts of the body. An animal of such a conformation, when exposed to any health-depressing influences, will certainly become affected by scrofula in one or other of its various forms. Neither management nor medicine can purify it of its inherent and ever-present tendency to disease. It must not, however, be supposed that scrofula invariably results from hereditary predisposition, for it may be induced even in the most healthy and vigorous stock by impure air, insufficient nutriment, and exposure to wet and cold. Thus many of the beasts and birds in our Zoological Gardens fall victims to scrofulous disease from being brought from a warm to a cold climate, or perhaps rather on account of the close atmosphere and artificial condition in which they are kept. Rabbits shut up in cold, damp, dark, and narrow boxes, and fed on food not suited to them, soon die of tubercular disease.* All influences inimical to health, and tending to repress the elimination of effete and poisonous matters from the body, are capable of inducing a strumous constitution, and always greatly aggravate any inherent tendency to it. Scrofulous disease, when thus produced by external circumstances, is always more manageable, and more capable of cure, than when hereditary; but in whatever manner produced, it is, like other constitutional diseases, accom-

* Watson's Principles and Practice of Physic. Third Edition, vol. i., p. 205.

panied by specific inflammation, very apt to become permanently hereditary.

The scrofulous taint is sometimes so strong as to affect the fœtus, and lambs are occasionally born with tuberculous deposits in their lungs and other parts of the body, and with collections of pus in and about the joints. During the fœtal state tubercles are also sometimes formed on the membranes of the brain, causing effusion into its cavities and enlargement of the head, which thus presents a serious obstacle to parturition. This state of fœtal tuberculosis induces the disease generally known as *hydrocephalus*, or water in the head. It is occasionally congenital, but more frequently appears a few weeks or months after birth, and is then indicated by the following well-marked symptoms. The lamb is dull and stupid, careless about its food and impatient of light. It hangs its head, grinds its teeth, totters in its gait, and becomes constipated and feverish. The head is sometimes much enlarged, especially in young subjects, from the soft and yielding nature of their cranial bones. Most cases terminate fatally within a few days, although some run on for several weeks. After death, numbers of opaque, yellowish white, granular bodies, varying from the size of a pin's head to that of a small nut, are found scattered over the surface of the pia mater, and apparently sunk into the convolutions of the brain, from their following the course of the veins. The substance of the brain is often much softened, and serum in greater or less amount is found in the ventricles and within the arachnoid, which becomes opaque, while the other membranes of the brain are congested, and sometimes thickened. Minute granules, exactly analogous to those within the cranium, are also found in other parts of the body, as in the intestinal and bronchial glands, and in the lungs. In adults, although not so frequently as in lambs, the brain is sometimes the seat of scrofulous deposits, usually single or only few in number, and often the size of a walnut. Such appearances are not uncommon in pulmonary consumption and in rot.

Tabes mesenterica is a variety of scrofulous disease, sometimes occurring in lambs and *one-shear* sheep. It consists in a deposit of tuberculous matter in the mesenteric glands, and is but consumption affecting the viscera of the abdomen instead of those of the chest. It is recognisable by capricious appetite, irregularity of the bowels, and general wasting and debility. These and the other symptoms of the disease depend on impaired digestion and assimilation caused by the deposit of thick, cheesy matter, in the lacteal vessels and glands. Granular matter, of an undoubtedly scrofulous type, is also effused on the intestinal mucous membrane, and occasionally upon the peritoneal

surfaces, where it gives rise to more acute symptoms, and causes much tenderness and pain of the abdomen. The lungs and bronchial glands also participate in the disease, though to a less extent than in adults. It does not, we believe, come within the scope of the present essay to notice the treatment of disease; but we may mention that the treatment of tabes mesenterica is not generally very satisfactory; for in this, as in all hereditary diseases, the chief and immediate cause defies removal. Good feeding—especially of an oleaginous kind—nursing, and attention to general health and comfort, will often mitigate the malady and sometimes subdue it for a time, but exposure to any untoward circumstances will be very apt to cause its recurrence, or lead to the development of pulmonary consumption.

When a scrofulous constitution presents itself prominently in an adult sheep, it is generally in the form of pulmonary consumption, or, as it is technically termed, *phthisis pulmonalis*. In this disease the tuberculous matter is chiefly deposited in the air cells of the lungs, or in the areolar tissue, and first appears as a dirty, greyish-yellow, glairy matter, consisting of imperfectly elaborated cells mixed up with granules. After a variable but usually short time, this deposit increases in quantity and in hardness, becoming of a cheesy consistence, and filling up the cavities of some of the air-cells to the obstruction of respiration. The consequent irritation causes a frequent cough, which is at first clear and unaccompanied by apparent pain, but which afterwards becomes short, difficult, and evidently painful. In this stage percussion yields a dull sound, and auscultation discovers a harsh noisy kind of breathing; but such indications vary much in the different stages of the disease, and can only be properly understood and appreciated by the well-trained ear. The number of respirations is increased to about five-and-twenty per minute—a natural provision for the oxidation of as much blood as possible by the parts of the lungs still remaining sound. The pulse, which in sheep may be felt either over the heart or in some of the larger arteries of the limbs, is generally about 80—weak, compressible, and easily accelerated by any kind of excitement. The appetite is capricious, and rumination performed very imperfectly, if at all. Such symptoms may continue with very little variation for many weeks or even months. During this time the tubercular deposits may soften and lose by absorption their more fluid and liquefiable parts, leaving dry, shrivelled, chalky masses; or during the progress of softening and consequent separation from their previous connexion, or by ulcerative action affecting the walls of the cavities thus formed, hemorrhage arises from the exposed blood-vessels—an occurrence, however, which is rare among the lower animals. Where neither of these

comparatively favourable terminations occurs, the case gradually becomes worse, a slow sub-acute inflammation being usually established, attended by effusion of more tubercular matter and pus. Respiration and circulation are thus still more obstructed, the breathing is much accelerated, the pulse weak and scarcely perceptible, whilst pus and vitiated mucus gravitate from the nostrils, and serous effusions appear in various dependent parts. The glands about the throat and neck become hard and swollen, diarrhœa or dysentery speedily reduces the quantity of the blood, emaciation and debility go on rapidly increasing, and death ensues from the impure quality and deficient quantity of the blood. As in all other scrofulous complaints, tuberculous matter is, on *post mortem* examinations, found distributed more or less generally through the body, but especially in the glands and on the mucous surfaces. The upper and left parts of the lungs are those which are most usually affected—exactly the reverse of what obtains with ordinary inflammation, which most commonly attacks the lower parts and the right lung. As we have already adverted at some length to the hereditary nature of the scrofulous habit of body, it is scarcely necessary to add any further remarks concerning the hereditary nature of consumption, which is merely one of the prominent forms in which that habit manifests itself. It may not, however, be uninteresting to exhibit the following table, given by Dr. Cotton,* as illustrating, in the human subject, "the influence of hereditary predisposition in a thousand cases of phthisis :"—

Predisposed.							Not Predisposed.	
Father consumptive.		Mother consumptive.		Both Parents consumptive.		Brothers or Sisters consumptive.		
M.	F.	M.	F.	M.	F.	M. and F.	M.	F.
59	53	40	62	15	12	126	393	240
367							633	

According to this table somewhat more than a third of the cases of consumption met with in ordinary practice owe their development to inherent hereditary causes. This is probably, however, rather a low estimate, for the parents registered as "predisposed" included those only in which the disease had presented itself in an obvious and decided manner; while there

* On the Nature, Symptoms, and Treatment of Consumption, by Richard P. Cotton, M.D. London, 1852, p. 61.

is little doubt that many of the "not predisposed" possessed a latent hereditary taint, which naturally descended to their own progeny. Dr. Cotton's table further shows that consumptive males are more apt to procreate consumptive sons, and consumptive females consumptive daughters—a fact which we have already noticed in our general observations; and, also, that while there is no apparent predisposition, men are more apt to become consumptive than women, in the proportion of 67·5 per cent. to 57·4 per cent.—a conclusion which may in great part be accounted for by their more irregular lives, and their more frequent exposure to health-depressing influences.

But these are not the only evils which assail sheep of a scrofulous constitution. They are occasionally affected by chronic swellings about the neck and throat, at first hard, but afterwards softening, bursting externally, and discharging an unhealthy pus. These swellings are analogous to clyers in cattle, and like them are most apt to occur in scrofulous subjects living in localities exposed to east winds. Scrofulous sheep are likewise subject to intractable swellings of the joints; to foot-rot in its most tedious and aggravated forms; and to rickets, a disease of the bones occurring in early youth from perverted nutrition, and consisting in a softening of the osseous tissue. They are further of such a weak and depraved constitution as to fall easy and early victims to any ordinary or prevailing diseases, which, moreover, are in them developed with unusual severity.

We have now noticed the chief diseases of sheep which are either hereditary or capable of becoming so; and would earnestly and conscientiously urge sheep-breeders to avoid all animals affected by these diseases, or exhibiting any of the external characters which indicate a tendency to them. But animals used for breeding purposes must not only have the negative quality of freedom from disease, but also the positive qualities of high health and vigour, without which no stock can ever be useful or profitable. And in order that they may be of the highest possible value as living manufactories of food and clothing they must further possess symmetry of form, and as great perfection as possible in all their parts. The head should be small in proportion to the body, and well covered with wool and hair, for a large coarse head is inconsistent with a proper symmetry among other parts, and indicates a dull sluggish temperament, and an indisposition to accumulate fat. The cheeks should be fine and thin; the nostrils expanded and moistened with healthy mucus; and the eyes full and clear, but at the same time soft and placid, as indicating that quiet and complacent disposition so essential in all animals intended for fattening. The neck must be fine at its junction with the body, but large, round, and deep where it

meets the chest, for a small thin neck, especially in the ram, is generally an indication of weakness and want of stamina. The chest should be wide and deep, in order to allow sufficient room for the free action of the lungs. Thin narrow-chested sheep always consume an amount of food disproportionate to their improvement in weight and condition, and are especially prone to diseases of the respiratory organs. The shoulders ought to be widely apart, and thickly invested with muscle; and the arm straight, strong, and covered with well-developed flesh, which should extend down nearly to the knee. This, like all the other joints, should be of good size and well-proportioned. Below the knee and hock, the bones should be neither too thick and coarse, nor too small and fine; for the former fault, besides being unsymmetrical, evidences a proclivity to rheumatic affections; and the latter, though indicating a disposition to arrive early at maturity, is generally an evidence of want of vigour. The back should be straight, broad, and well-covered with muscle. The ribs should be attached to the spine almost at right angles, well arched, and extending far back so as to diminish as much as possible the space between the last rib and the prominence of the haunch. The pelvis should be square and large in order to allow of the ample deposition of muscle and fat. The tail should be well set on, giving the quarters a square or round appearance. A sheep with thin, angular, ragged quarters and a badly set on tail, with the usual accompaniment of a large flat belly, will never thrive well, and will, moreover, be very liable to suffer from diarrhœa and dysentery. The loins should be thickly covered both outside and in with well-developed muscle, for being parts particularly prized by the butcher they cannot well be too large. The legs must be short in proportion to the size of the body, for animals of this conformation are always found to thrive and fatten best. The skin should be thin, fine, and mellow, and the wool abundant and of medium fineness. Curly wool sometimes shows a special tendency to fatten, and bareness of wool about the head, legs, or belly is always an indication of a delicate constitution. A sheep of any breed whatever, if possessed of these good points, thus briefly noticed, will be of a strong and vigorous constitution, and exempt from all hereditary defects and diseases, will arrive early at maturity, thrive well, and fatten rapidly.

III. *Hereditary Defects and Diseases of Pigs.*—Pigs, when carefully managed, are hardy and little liable to disease. The wild breeds in both the old and new worlds are remarkably healthy; but it must be recollected that they constantly breathe pure fresh air, have regular exercise, feed moderately on roots and fruits, and carefully avoid all kinds of filth, for they are

naturally a very cleanly race, and indulge in wallowing in the mire not from any love of filth, as is generally supposed, but, like the elephant, rhinoceros, and other Pachydermata, for the purpose of protecting their skins from the attacks of insects. In a state of domestication, however, their condition is usually very different. They are cooped up in narrow, damp, and dirty styes, and constrained to inhale all kinds of noxious vapours, and to eat coarse, innutritious, and unsuitable food. We cannot then be surprised that under such circumstances they should not only become the victims of disease, from which in their natural state they are free, but should also transmit to their progeny a weakened and morbidly-predisposed constitution. But we believe that much of the hereditary disease of pigs is due to another cause than that just indicated, viz., breeding in and in. This practice is often pushed to an excessive and injudicious extent in these animals; and from their coming early to maturity, and producing a numerous progeny at one birth, it causes in them a marked deterioration in a comparatively short space of time. In several cases which have come under our own observation, it has induced total ruin of the entire stock. At first it merely rendered the animals somewhat smaller and finer than before, and improved rather than injured their fattening properties. Very soon, however, it caused a marked diminution in size and vigour, and engendered a disposition to various forms of scrofulous disease, as rickets, *tabes mesenterica*, and pulmonary consumption. Many of the boars became sterile, and the sows barren or liable to abortion. In every succeeding litter the pigs became fewer and fewer in number, and more and more delicate and difficult to rear. Many were born dead, others without tails, ears, or eyes; and all kinds of monstrosities were frequent. Such is the complicated train of evils resulting from the infringement of that natural law which forbids sexual intercourse between animals nearly related to each other.* The occurrence of such effects should induce breeders of swine, and indeed of all animals, to practise breeding in and in with much caution, to adopt it only occasionally and with strong and healthy animals, and to recollect that, though it may improve

* Dr. Whitehead, in speaking of the evils resulting from marriages between those too nearly related to each other, remarks—" A very little reflection will suffice to show, that a particular temperament or disposition, prominently developed, and especially if existing simultaneously in both husband and wife, will be likely to be reproduced, still further exaggerated, in the offspring, and thus that healthy balance, so necessary to the harmonious discharge of the nervous and circulatory functions, is at length destroyed, merging itself in incapability and disease. It is not improbable that a succession of evils arising in this manner necessitated the enactment of that portion of the Levitical code which prohibits intermarriage within certain degrees of kindred—a law which has been respected, with tolerable exactness, in most civilized countries, to the present day."—Whitehead on 'Some Forms of Hereditary Disease,' 1851, pp. 4, 5.

the symmetry and fattening capabilities of stock, it does so at the sacrifice of their general vigour and disease-resisting powers.

Pigs are subject to most of the hereditary diseases of sheep, and in discussing this part of our subject we shall follow the same order as in Section II.

Pigs are often attacked by *epilepsy*, which sometimes comes on very suddenly, distorting the countenance, especially the eyes, convulsing in the most violent manner all the muscles, obstructing the respiration, accelerating the pulse, and leaving the animal in a stupid, frightened state, from which it slowly recovers, often only to be again and again attacked in a similar manner at variable intervals of some hours, days, or weeks. The occurrence of an epileptic attack is sometimes preceded by restlessness and irritability, or by loss of appetite and dulness, and is often traceable to some derangement of the digestive organs, and especially to constipation. The attacks often occur again and again without leaving any obvious change of structure in the brain or nervous system. In all such cases, however, some change of minute structure, though invisible to our present means of observation, must we believe exist; and there appears to be sufficient evidence of this in the fact of the disease being so specially apt to attack those animals that have once suffered from it. Now this altered condition of the brain is as much a part and quality of the individual as the shape of the snout or the appearance of the tail, and like these more external and palpable characters is capable of hereditary transmission. To mitigate an inherent tendency to epilepsy, the animals must be kept very clean, warm, and comfortable, and supplied with a sufficiency of good digestible and somewhat laxative food. To eradicate it, the stock must receive an infusion of new blood, and this is especially necessary, as epilepsy in pigs depends in most cases on continued breeding in and in.

A predisposition to *lung diseases*, and especially to bronchitis and pneumonia, sometimes appears hereditary among pigs, and is often indicated by a narrow chest, a general lanky and thriftless appearance, and a great liability to suffer from coughs, readily excited by slight exposure to cold or wet, or even by changes of food.

Among various of the larger and less improved varieties of pigs, many individuals may still be found with narrow carcases, flat ribs, a general coarse and washy appearance, and a want of balance and proportion among the more important organs of the body. Animals of such a formation are long in coming to maturity, consume large quantities of food, fatten slowly, and are moreover unusually liable to almost all disorders of the digestive organs, and especially to indigestion, with its usual symptoms of

loss of appetite, and irregularity of the bowels—to colic, with flatulence and griping—to diarrhœa, obstinate, long-continued, and often recurring—and to *enteritis* or inflammation of the intestines, accompanied by its usual symptoms of uneasiness, flatulence, loss of appetite, frequent and severe colicky pains, and more or less tenderness of the abdomen, evinced especially when pressure is applied over the right iliac region. In enteritis the fluid fæces are sometimes tinged with blood, and the pulse is small and rapid. As the disease approaches a fatal termination there is much dullness, nausea, and general prostration. On dissection it is generally found that the posterior parts of the small intestines have suffered most, that the large intestines are also involved, though to a less extent, and that the inflammation has chiefly located itself in the vessels lying immediately within the mucous coat, but has also sometimes extended to the serous, and in bad cases to the muscular coat. Enteritis and the various disorders just mentioned are of exceedingly common occurrence among pigs possessed of that faulty external organisation which we have above described; and as this faulty organisation is notoriously hereditary, those weaknesses and diseases depending on it must be hereditary likewise.

Pigs, from their susceptibility to cold, are often attacked by *rheumatism*, especially in its more chronic forms. This is a constitutional disease, depending on the presence in the blood of some poisonous materials, probably analogous to those found within the gouty joints of man. Like other constitutional diseases, it is accompanied by certain local symptoms. In pigs it chiefly affects the fibrous and serous tissues of the larger joints, gives evidence of local inflammation and general fever, progresses with slow and lingering steps, and does not, like ordinary inflammation, terminate in suppuration and gangrene. It most commonly occurs among young pigs, and usually owes its origin to lying in a wet cold bed. It always produces alteration of structure in the parts affected, which predisposes the individual to subsequent attacks, and tends to reappear in the progeny, rendering them also specially predisposed to the complaint.

Scrofula is more common in pigs than in any of the other domesticated animals. It sometimes carries off whole litters before they are many weeks old; and, as in sheep, presents itself in several different forms, but especially in that of pulmonary consumption, which is very common and fatal among many of the more improved varieties of swine. In pigs, consumption exhibits the same symptoms as in other animals—gradually increasing emaciation; imperfect digestion and assimilation; disturbed respiration, with a frequent, short, hacking cough; weakened and unusually accelerated circulation; diarrhœa of a most

intractable kind, often merging into dysentery, and general prostration of the vital powers. It generally runs its course more rapidly than in cattle or sheep, and leaves after death many appearances showing that it is a constitutional, and not, as some have thought, a local disease. The tubercles and pus are not confined to the lungs, but are also found in the bronchial, mesenteric, and intestinal glands, in the liver, and occasionally in the brain. The muscles are soft and blanched, for the system, for some time before death, has had at its disposal only small quantities of very deteriorated blood. This is found thin, dark-coloured, and of a noisome odour. Every one who has had much experience in the breeding of pigs must be well aware of the hereditary nature of consumption, and many illustrative cases could be mentioned. Some years ago it got among the pigs of an eminent distiller near this place, who lost several scores by it, and got rid of it only after it had continued for several generations. We have lately seen it in various degrees of intensity among several different stocks, and the owners, intelligent farmers of accurate observation and much experience, inform us that they have almost always found it strikingly and decidedly hereditary.

Scrofulous tumours are sometimes met with among pigs. They most commonly affect the lymphatic glands lying within the angle of the jaw, but sometimes also involve the parotid and other salivary glands. They are produced by the effusion of degenerated lymph, incapable of perfect organisation, and mixed up with tuberculous matter. The swelling, at first small, hard, and painless, gradually increases in size, and softens. The skin overlying it ulcerates, and a yellow semifluid flaky matter is poured out. The wound is unhealthy, surrounded by soft granulations, difficult to heal, and when healed apt to break out again. These local symptoms are often accompanied by some of the usual constitutional symptoms of scrofula, as impairment of digestion and assimilation.

There is a curious accident to which pigs of a delicate and scrofulous constitution are occasionally liable, viz. dropping away of the tail. The writer is acquainted with the case of a breed affected in this way, a considerable portion of the tail gradually separating by ulceration, and leaving a stump usually somewhat less than an inch long. This occurs almost always when the pigs are about six weeks old, and has now continued for a good many generations.

Cancerous tumours are said sometimes to occur in pigs. In other animals, as in cattle, these tumours are of a very malignant kind, cause much pain and constitutional derangement, and rapid

destruction of the parts among which they are placed. They are mere local symptoms of a general disorder, and are always hereditary. Among pigs, however, we have never seen any truly cancerous tumours, though we have sometimes met with scrofulous tumours bearing some resemblance to them. From the fact that cancerous tumours are hereditary in all animals in which they occur, we have no doubt that when they do occur in pigs they will in them likewise be hereditary.

In conclusion, we may repeat that many of the most common, and some of the most serious diseases of sheep and pigs are hereditary; and that they spring from certain vices of structure or disproportion of parts either of a local or general nature. They are propagated alike, whether occurring in the male or in the female parent, but always most certainly, and in the most aggravated form, when occurring in both. Defects and diseases that have already been transmitted through several generations are impressed on the progeny in a most decided, permanent, and irremediable form. But those acquired during the lifetime of an individual also sometimes become hereditary, especially when of a constitutional nature, and accompanied by any considerable alteration of structure or function, or by a debilitated and deteriorated state of health. Indeed debility, however produced, is almost certain to be hereditary; and hence all breeding animals should be in a strong and vigorous condition, especially at the period of sexual congress.

In fine, the successful breeder either of sheep or pigs must ever recollect and act upon the familiar axiom, "like produces like." He must therefore select his stock with the best possible symmetry, and with those appearances which indicate vigour of constitution and freedom from disease, and must continually endeavour to maintain and improve excellences, and mitigate and remove deficiencies by judicious crossing and careful attention to sanatory arrangements.

Addendum.

Much difference of opinion prevails as to the relative influence of the male and female parent in determining the characters of the progeny. According to a very prevalent notion, the male bestows all valuable qualities, whether of form or of vigour; while the female is regarded merely as a passive instrument which hatches, as it were, the male seed—an absurd doctrine long preserved from well merited obloquy as a convenient excuse for carelessness and neglect in the selection of the female parent. A most ingenious hypothesis has lately been propounded by Mr. Orton of

Sunderland, in a paper published in the 'Newcastle Chronicle' of 10th March, 1854, and noticed at considerable length in the 'Monthly Medical Journal' for August of the same year. The male animal, according to Mr. Orton, influences especially the external, and the female the internal organization of the offspring. The outward form, general appearance, and organs of locomotion are chiefly determined by the male; the vital organs, size, general vigour, and endurance by the female. Many most interesting facts, of which we subjoin a few, are adduced in support of this proposition. There are many reasons for believing that Mr. Orton's views afford a clue to an important law of physiology. But this, it must be remembered, cannot be the only law operating in the process of generation, and as Mr. Orton himself states, it must consequently be liable to many modifications, and must only be accepted with certain restrictions. Thus the parent, which at the time of copulation is more powerful and vigorous, doubtless imparts to the progeny an unduly large share of its own prominent characters.

Mr. Harvey in commenting on Mr. Orton's paper makes the following observations:—

"The *mule* is the produce of the male ass and the mare; the *hinny* (or as it is called the *muto*), that of the horse and the she-ass. Both hybrids are the produce of the same set of animals. They differ widely, however, in their respective characters—the mule, in all that relates to its external characters, having the distinctive features of the ass—the hinny, in the same respects, having all the distinctive features of the horse; while, in all that relates to the internal organs and vital qualities, the mule partakes of the characters of the horse, and the hinny of those of the ass. Mr. Orton, speaking of this, says: 'The mule, the produce of the male ass and mare, is essentially a *modified ass;* the ears are those of an ass somewhat shortened; the mane is that of the ass erect; the tail is that of an ass; the skin and colour are those of an ass somewhat modified; the legs are slender, and the hoofs high, narrow, and contracted, like those of an ass; in fact, in all these respects it is an ass somewhat modified. The body and barrel of the mule are round and full, in which it differs from the ass, and resembles the mare. The hinny (or muto), on the other hand, the produce of the stallion and she-ass, is essentially a *modified horse:* the ears are those of a horse somewhat lengthened; the mane flowing; the tail is bushy, like that of the horse; the skin is finer, like that of the horse; and the colour varies also like the horse; the legs are stronger, and the hoofs broad and expanded, like those of the horse. In fact, in all these respects, it is a horse somewhat modified. The body

and barrel, however, of the hinny are flat and narrow, in which it differs from the horse, and resembles its mother the ass. The mule and hinny,' adds Mr. Orton, 'have been selected and placed first, because they afford the most conclusive evidence, and are the most familiar.' Equally conclusive, although perhaps less striking instances may be drawn from other sources. Thus it has been observed, that when the Ancona, or other sheep, are allowed to breed with common ewes, the cross is not a medium between the two breeds, but that the offspring retains in a great measure the short and twisted legs of the sire.

"Buffon made a cross between the male goat and ewe; the resulting hybrid in all the instances, which were many, were strongly characteristic of the male parent, more particularly so in the hair and length of leg. Curiously enough, the number of teats in some of the cases corresponded with those of the goat.

"A cross between a male wolf and a bitch illustrates the same law; the offspring having a markedly wolfish aspect, skin, colour, ears, and tail. On the other hand, a cross between the dog and female wolf afforded animals much more dog-like in aspect—slouched ears and even pied in colour. If you look to the descriptions and illustrations of these two hybrids, you will perceive at a glance that the doubt arises to the mind in the case of the first, 'What genus of *wolf* is this?' whereas in the case of the second, 'What a curious *mongrel dog!*'

"Amongst birds we have the same results, and they afford the like illustrations to our subject. Those who have had much to do with pigeons must have perceived that a cross between a *carrier* cock and a *dragoon* hen is always a fine bird, and very nearly equal to the carrier; whereas a cross between a dragoon cock and carrier hen results in nothing better than a dragoon. Precisely the same may be observed in the cross between the *tumbler* and *pouter*.

"'It is curious to observe,' continues Mr. Orton, 'that the proposition I make regarding male influence should not only have been observed, but distinctly stated in so many words. Mr. Lloyd says: 'The *capercailli* occasionally breed with the *black grouse*, and the produce are in Sweden called *racklelianen*. These partake of the leading characters of both parents, but their size and colour greatly depend upon whether they have been produced between the capercailli cock and grey hen, or *vice versâ* (Yarrell, p. 298). The hybrid between the pheasant and grouse is a striking illustration, showing so clearly its male parent: in almost all respects it is a pheasant, only the tail slightly shortened. It may be observed, too, that the feathered feet of the grouse have disappeared in the offspring (ibid. p. 309). Another

instance of the same cross is given (p. 311), in which the general characteristics are those of the pheasant; and this would have been still more striking if the tail had not been spread, a liberty, I suspect, either of the artist or the stuffer of the specimen. The legs in this instance are slightly feathered. Another hybrid is given (p. 313) between the *ptarmigan* and the grouse. Although the precise parentage of the bird is not stated, I am perfectly satisfied that in this case the grouse has been the male parent, and the tail indicated this, being somewhat forked and divergent. In your museum there is an interesting specimen illustrating the same law—a hybrid between the pheasant and grey hen. In this case the produce is pheasant-like in aspect, tail like the pheasant, but somewhat spread, no appearance of forking of the tail.'

"Even in the breeding of *fish* the same law has been observed. Sir Anthony Carlisle produced mule fish, by impregnating the spawn of the *salmon* by means of the male *trout.* The results I give in his own words:—'These mules partook of the character of the trout more than of the salmon. They had bright red spots on their sides, but the black colour was shaded downwards in bars like those of the perch. The tails were not forked like those of the salmon, as I have seen them in the Thames *skeggers* (from which I infer the male salmon in that case to have been the impregnators).' We thus see in the case of fish, as in that of animals, the male parent giving the external characteristics: those produced by the male trout had not forked tails; the skeggers, on the other hand, produced by the male salmon, had forked tails."

III.—*Experiments on the Comparative Fattening Qualities of Different Breeds of Sheep.* By J. B. Lawes, Esq., F.R.S., of Rothamsted, Herts.

No. 3.—Leicesters and Cross-breds.

In former numbers of this Journal, we have detailed the results of experiments upon the comparative fattening qualities of the Hampshire, and the Sussex Downs, and the Cotswold sheep; and, in our Report on the latter, we intimated our intention to institute in the succeeding season similar experiments with the Lincoln and Leicester breeds. This intention has, however, not been entirely carried out; for, on full inquiry as to the character of the so-called Lincoln sheep, and the present extent of its unmixed distribution, it was decided, that the comparison of it

with the Leicesters would be of less interest and utility than that of some other animals more closely comparable both by affinity and contrast with the latter breed. The well known and extensively adopted cross between the Leicester ram and the Sussex Down ewe was therefore selected for the next experiment. And, as both the *ewes* and *wethers* of the *cross*-breed are from the first fed for the butcher, it was thought that it might be useful to experiment separately upon each of them. An equal number then of *pure Leicesters*, of the *cross-bred wethers*, and of the *cross-bred ewes*, formed the subjects of the experiment now to be recorded.

After the full explanation which has been given in our former Reports, it is scarcely necessary again to remind the reader that the comparison sought to be instituted in this series of experiments with different breeds of sheep is limited to that of the adaptation of the respective breeds to a system of *rapid fattening*, upon a *liberal supply of food;* and, that it does not directly embrace the examination into their aptitude to different localities, and to widely different methods of feeding.

The general characters of the new Leicester sheep are too generally known, and too well described elsewhere, to render any lengthened account suitable to our present purpose. Its remarkable aptitude to develop flesh and *carcass fat*, and to come to early maturity, are the qualities by which, in a word, it may be said to be characterized, when compared with most of the breeds currently adopted under the comparatively modern system of high feeding. And it is by combining these qualities of the Leicester sheep with the better fleece, the greater hardiness, the greater fecundity, and the better nursing qualities of the Sussex Down, that the cross between the *Leicester ram* and the *Sussex ewe* has been found to be one of the most successful of the breeds or crosses which it has been sought to adapt to the system of liberal feeding which now characterizes the sheep farming of a large proportion of the best cultivated districts of the country.

The experiments about to be recorded were made in the winter and spring of 1852-3.

Fifty Leicester wether lambs were kindly selected by Mr. Cresswell, of Ravenstone, near Ashby-de-la-Zouch, in October, 1852. At that time, owing to the abundance of keep, store sheep were exceedingly dear. And, it was even with some difficulty that 50 good and pure lambs suited to the purpose, could be obtained at anything like a reasonable price. Nor could it be done at all, except from several different flocks.

The 50 Leicester wether lambs at length selected arrived at Rothamsted, on October 24, 1852. The cost was 35*s.* per head

irrespective of expenses. Mr. Cresswell stated, that on comparing these wethers with his own ram lambs, he considered them not to be quite so large as could be wished; and he supposed from their appearance that their growth had been somewhat checked by the scarcity of food in the previous spring and summer. Upon the whole, however, the sheep were a good and even lot; and they may doubtless be taken as fully if not more than equal to the average of the breed in ordinary use.

The cross-breds were supplied by Mr. Edmund Farrer, of Spoole, near Swaffham, Norfolk. They were the produce of South Down ewes, with Leicester rams from the flock of Mr. Aylmer. Sixty of the cross-bred lambs—ewes and wethers indiscriminately—arrived at Rothamsted on October 24, 1852. This lot cost 32*s.* per head. Twenty-five more from the same flock—mixed ewes and wethers—were also received on November 13th; and this second lot cost 33*s.* per head.

All the experimental sheep, both Leicester wethers, and cross-bred ewes and wethers, were turned into a meadow as they arrived; and supplied at once with some pulled turnips, in order to accustom them to such food. On November 15th, all were put upon the rafters under cover, where the experiment was to be conducted; and, on November 18, each animal was separately weighed—the wool being by this time dry. At this date, 40 each, of the most even of the Leicester lambs, of the cross-bred wethers, and of the cross-bred ewes, were selected; and, from this time, until December 2, when the exact experiment commenced, they were allowed half the quantity of *dry* food which they would afterwards receive, and in addition, as many turnips as they chose to eat.

As with the Hampshire and Sussex Downs, and Cotswolds in the previous experiments, *oil-cake* and *clover-chaff* were the *dry* foods employed; and Swedish turnips the green food.

The quantities per head per day of the dry foods, were allotted exactly in the same proportion to the average weights of the sheep, as in the experiments with the other breeds. It may here be noticed in passing, that the average weight of the Sussex sheep of the former experiment at its commencement, was 88 lbs.;—that of the Hampshires was $113\frac{3}{4}$ lbs.;—and that of the Cotswold $113\frac{1}{2}$ lbs. That of the sheep now under consideration was, for the Leicesters $101\frac{1}{4}$ lbs.; for the cross-bred wethers 95 lbs.; and for the cross-bred ewes $91\frac{1}{4}$. It was then exactly in proportion to these respective weights, that the daily supply of dry food was allotted per head for each of the six different breeds.

At the time of the first weighing and selection of the 40 each—

Leicester wethers, cross-bred wethers, and cross-bred ewes—one of each was also selected of nearly the average weight, and of pretty uniform character with the 40 of its lot to be put under experiment; and, this single sheep of each lot, as in the case of the Cotswolds, was killed at once, in the store condition, in order to have the means of comparing the proportional weights of the carcass, and of the various parts of the offal, of the different sheep, in the *store*, and in the *fat* condition. As also in the case of previous experiments, a few of each kind were turned out into the field with the ordinary fattening flock of the farm.

The results of the experiments with the Leicester wether lambs and the cross-bred ewes and wethers, are given in the Tables which follow in the same detail as has already been done for the other breeds. But as it is not our intention, at any rate for the present, to pursue this line of experiment with any other breeds, and as we propose therefore to give a comparative summary of the results of the six breeds in the present paper, we shall not discuss separately at such length as formerly the details relating to the three lots which constitute the subject of the present Report.

In Tables I., II., and III., pp. 49, 50, and 51, are given, for each lot respectively:—

The weight of each sheep at the commencement of the experiment, Dec. 2, 1852;

The gain in weight of each sheep during each experimental period of 4 weeks;

The weight of wool from each sheep, shorn April 7, 1853;

The total increase of each sheep (including wool), during the total period of the experiment, namely 20 weeks;

The final weights, both inclusive and exclusive of wool;

And, in the 12th column, the *average weekly gain* of each sheep during the 20 weeks.

There are also given at the foot of these Tables, the total weight of the lot of 40 sheep at the beginning and at the end of the experiment, the latter both inclusive and exclusive of wool; the total increase during each period of 4 weeks and the total period of 20 weeks; as also the total wool. And, in the lower line, the means, or *weekly average* per head, as the case may be, of each of these particulars.

TABLE I.

Table I.

Increase, &c., of each of the Leicester Sheep.

Sheep. Nos.	Weights at commencement, Dec. 2.	Increase in 4 Weeks to Dec. 30.	Increase in 4 Weeks to Jan. 27.	Increase in 4 Weeks to Feb. 24.	Increase in 4 Weeks to Mar. 24.	Wool Shorn, April 7.	Increase (including Wool) in 4 Weeks to Apr. 21.	Total Increase (including Wool) in 20 Weeks.	Final Weight with Wool.	Final Weight without Wool.	Average Increase per head per Week.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs.	lbs. ozs.
1	112	7	— 2	16	12	9 4	9 4	42 4	154 4	145	2 2
2	118	8	5	16	14	7 13	10 13	53 13	171 13	164	2 11
3	105	7	2	12	12	9 2	11 2	44 2	149 2	140	2 3
4	108	5	4	9	12	6 5	8 5	38 5	146 5	140	1 15
5	119	14	13	15	14	10 4	10 4	66 4	185 4	175	3 5
6	105	7	1	9	4	11 4	10 4	31 4	136 4	125	1 9
7	96	— 2	— 2	16	9	6 0	10 0	31 0	127 0	121	1 8¾
8	108	8	9	15	12	10 0	12 0	56 0	164 0	154	2 13
9	118	4	3	13	9	12 6	8 6	37 6	155 6	143	1 14
10	95	9	1	11	12	7 4	10 4	43 4	138 4	131	2 2
11	117	9	10	13	12	10 0	18 0	62 0	179 0	169	3 1
12	114	5	9	12	12	8 3	8 3	46 3	160 3	152	2 5
13	112	10	3	10	9	6 3	7 3	39 3	151 3	145	1 15
14	121	12	5	16	14	8 12	15 12	62 12	183 12	175	3 2
15	91	9	6	9	12	6 3	5 3	41 3	132 3	126	2 1
17	105	7	3	13	12	8 5	10 5	45 5	150 5	142	2 4
18	105	7	0	10	17	6 10	7 10	41 10	146 10	140	2 1
19	91	9	7	12	7	7 12	13 12	48 12	139 12	132	2 7
20	98	5	7	5	11	6 11	6 11	34 11	132 11	126	1 12
21	102	8	3	15	12	9 4	12 4	50 4	152 4	143	2 8
22	104	8	— 2	12	12	8 10	7 10	37 10	141 10	133	1 14
23	92	4	2	7	7	8 9	11 9	31 9	123 9	115	1 9
24	91	10	5	13	14	8 8	8 8	50 8	141 8	133	2 8
25	105	9	8	11	15	8 14	11 14	54 14	159 14	151	2 12
26	112	8	— 7*	23	14	9 9	9 9	47 9	159 9	150	2 6
27	94	10	8	10	11	9 13	9 13	48 13	142 13	133	2 7
28	100	10	3	13	12	6 14	7 14	45 14	145 14	139	2 5
29	100	8	4	12	8	8 4	8 4	40 4	140 4	132	2 0
30	98	8	4	11	12	7 0	14 0	49 0	147 0	140	2 7
31	94	4	7	16	12	7 14	7 14	46 14	140 14	133	2 5
32	93	10	1	— 2	7	9 12	9 12	25 12	118 12	109	1 4
34	88	12	2	10	9	6 14	8 14	41 14	129 14	123	2 1
35	84	0	— 4	12	11	6 11	4 11	23 11	107 11	101	1 3
36	89	5	0	18	8	8 7	14 7	45 7	134 7	126	2 4
37	101	7	2	16	14	9 3	13 3	52 3	153 3	144	2 10
39	94	10	0	15	6	7 0	6 0	37 0	131 0	124	1 13
40	91	5	7	9	10	6 8	10 8	41 8	132 8	126	2 1
41	105	7	— 1	11	11	5 10	8 10	36 10	141 10	136	1 13
42	88	6	3	19	17	7 14	7 14	52 14	140 14	133	2 10
43	90	11	11	14	12	6 6	9 6	57 6	147 6	141	2 14
Totals	4053	300	140	497	450	325 13	395 13	1782 12	5835 13	5510	88 12¼
Means, and Average Weekly Gain per head during each Period.	Mean per Head. lbs. oz. 101 5	lbs. ozs. 1 14	lbs. ozs. 0 14	lbs. ozs. 3 1¼	lbs. ozs. 2 13	Mean per Head. lbs. ozs. 8 2¼	lbs. ozs. 2 7½	Mean per Head. lbs. ozs. 44 9	Mean per Head. lbs. ozs. 145 14	Mean per Head. lbs. ozs. 137 12	lbs. ozs. 2 3½

* Lame.

Table II.

Increase, &c., of each of the Cross-bred Wethers.

Sheep. Nos.	Weights at commencement, Dec. 2.	Increase in 4 Weeks to Dec. 30.	Increase in 4 Weeks to Jan. 27.	Increase in 4 Weeks to Feb. 24.	Increase in 4 Weeks to Mar. 24.	Wool Shorn, April 7.	Increase (including Wool) in 4 Weeks to Apr. 21.	Total Increase (including Wool) in 20 Weeks.	Final Weight with Wool.	Final Weight without Wool.	Average Increase per head per Week.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs.	lbs. ozs.
1	91	9	8	9	11	5 8	10 8	47 8	138 8	133	2 6
2	95	13	7	11	14	5 7	7 7	52 7	147 7	142	2 10
3	88	11	11	10	13	8 12	11 12	56 12	144 12	136	2 13
4	93	9	8	7	12	5 10	6 10	42 10	135 10	130	2 2
5	89	9	9	7	12	8 5	7 5	44 5	133 5	125	2 3
6	95	12	5	11	13	4 12	4 12	45 12	140 12	136	2 4
7	89	9	4	12	8	5 7	9 7	42 7	131 7	126	2 2
8	100	6	2	10	11	7 8	5 8	34 8	134 8	127	1 11
9	96	9	9	11	14	7 12	6 12	49 12	145 12	138	2 8
10	94	8	9	7	8	6 15	6 15	38 15	132 15	126	1 15
11	101	11	4	6	14	5 8	9 8	44 8	145 8	140	2 3
12	102	10	8	15	15	6 12	5 12	53 12	155 12	149	2 11
13	104	6	5	7	11	6 11	8 11	37 11	141 11	135	1 14
14	100	12	0	10	13	6 8	7 8	42 8	142 8	136	2 2
15	93	11	10	12	14	7 0	9 0	56 0	149 0	142	2 12
16	93	9	9	12	14	6 0	9 0	53 0	146 0	140	2 10
17	99	9	8	11	16	7 10	11 10	55 10	154 10	147	2 12
18	101	13	6	5	15	5 7	1 7	40 7	141 7	136	2 0
19	96	6	10	10	11	6 13	6 13	43 13	139 13	133	2 3
20	98	3	8	10	11	6 9	12 9	44 9	142 9	136	2 4
21	95	9	7	4	8	6 2	9 2	37 2	132 2	126	1 13
22	96	10	5	9	13	5 9	5 9	42 9	138 9	133	2 2
23	94	8	8	10	8	6 13	5 13	39 13	133 13	127	1 15
24	100	10	6	12	12	6 10	8 10	48 10	148 10	142	2 7
25	98	14	4	10	15	7 14	5 14	48 14	146 14	139	2 7
26	102	10	7	11	12	5 4	5 4	45 4	147 4	142	2 4
27	100	10	5	7	11	6 2	6 2	39 2	139 2	133	1 15
28	98	5	11	10	14	4 4	7 4	47 4	145 4	141	2 6
29	87	9	8	8	10	6 4	7 4	42 4	129 4	123	2 2
30	88	5	7	7	12	5 6	5 6	36 6	124 6	119	1 13
32	98	8	10	12	12	7 0	7 0	49 0	147 0	140	2 7
33	88	6	7	11	11	6 12	9 12	44 12	132 12	126	2 4
34	86	12	12	9	13	6 7	6 7	52 7	138 7	132	2 10
35	98	3	2	9	11	6 7	8 7	33 7	131 7	125	1 11
36	91	6	5	10	10	5 13	5 13	36 13	127 13	122	1 13
37	86	6	7	12	11	6 14	6 14	42 14	128 14	122	2 2
38	98	7	7	10	14	6 12	10 12	48 12	146 12	140	2 7
39	98	12	4	12	10	5 12	2 12	40 12	138 12	133	2 0
40	91	9	7	9	12	6 0	2 0	39 0	130 0	124	1 15
41	95	6	7	8	10	8 3	7 3	38 3	133 3	125	1 14
Totals	3804	350	276	383	479	257 2	292 2	1780 2	5584 2	5327	88 8
Means, and Average Weekly Gain per Head during each Period.	Mean per Head. lbs. oz. 95 1½	lbs. ozs. 2 3	lbs. ozs. 1 11½	lbs. ozs. 2 6	lbs. ozs. 3 0	Mean per Head. lbs. ozs. 6 7	lbs. ozs. 1 13¼	Mean per Head. lbs. ozs. 44 8	Mean per Head. lbs. ozs. 139 9¼	Mean per Head. lbs. ozs. 133 3	lbs. ozs. 2 3¼

Table III.

Increase, &c., of each of the Cross-bred Ewes.

Sheep. Nos.	Weights at commencement, Dec. 2.	Increase in 4 Weeks to Dec. 30.	Increase in 4 Weeks to Jan. 27.	Increase in 4 Weeks to Feb. 24.	Increase in 4 Weeks to Mar. 24.	Wool Shorn, April 7.	Increase (including Wool) in 4 Weeks to Apr. 21.	Total Increase (including Wool) in 20 Weeks.	Final Weight with Wool.	Final Weight without Wool.	Average Increase per head per Week.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs.	lbs. ozs.
1	91	13	2	10	10	7 4	14 4	49 4	140 4	133	2 7
2	92	11	7	9	7	8 4	7 4	41 4	133 4	125	2 1
3	100	5	6	10	7	7 12	8 12	36 12	136 12	129	1 13
4	86	8	7	11	10	7 8	7 8	43 8	129 8	122	2 3
5	93	9	4	13	10	9 4	9 4	45 4	138 4	129	2 4
6	91	7	11	10	10	7 6	13 6	51 6	142 6	135	2 9
7	95	10	6	11	11	7 10	10 10	48 10	143 10	136	2 7
8	93	5	6	16	11	8 12	7 12	45 12	138 12	130	2 4
9	95	7	6	11	12	6 14	14 14	50 14	145 14	139	2 8
10	98	12	5	11	7	5 10	7 10	42 10	140 10	135	2 2
11	94	9	1	15	9	6 4	6 4	40 4	134 4	128	2 0
12	89	7	0	4	11	6 7	7 7	29 7	118 7	112	1 7
13	90	10	5	14	13	5 8	6 8	48 8	138 8	133	2 7
14	92	6	3	11	7	6 6	6 6	33 6	125 6	119	1 10
15	87	9	8	13	7	7 3	5 3	42 3	129 3	122	2 2
16	98	9	5	7	9	9 12	14 12	44 12	142 12	133	2 4
17	98	10	3	9	9	6 10	6 10	37 10	135 10	129	1 14
18	100	2	7	13	12	6 0	5 0	39 0	139 0	133	1 15
19	86	5	8	13	10	7 10	7 10	43 10	129 10	122	2 3
20	90	2	8	12	10	8 5	3 5	35 5	125 5	117	1 12
21	91	7	3	10	8	5 8	5 8	33 8	124 8	119	1 11
22	94	10	3	12	11	7 2	10 2	46 2	140 2	133	2 5
23	98	6	6	10	11	6 8	10 8	43 8	141 8	135	2 3
24	84	8	5	11	11	7 4	5 4	40 4	124 4	117	2 0
25	88	0	7	13	11	6 14	9 14	40 14	128 14	122	2 0½
26	96	6	7	10	8	7 12	10 12	41 12	137 12	130	2 1
27	98	3	8	10	8	6 5	7 5	36 5	134 5	128	1 13
29	78	8	5	14	12	7 13	4 13	43 13	121 13	114	2 3
30	94	8	7	10	10	7 10	10 10	45 10	139 10	132	2 4
31	79	8	3	11	11	6 7	6 7	39 7	118 7	112	1 15
32	86	12	5	9	10	6 1	7 1	43 1	129 1	123	2 2
33	89	9	6	3	17	7 0	8 0	43 0	132 0	125	2 2
34	98	4	10	10	11	6 14	9 14	44 14	142 14	136	2 4
35	84	11	12	14	12	7 14	10 14	59 14	143 14	136	3 0
36	92	2	11	10	9	7 4	9 4	41 4	133 4	126	2 1
37	88	10	4	11	10	7 8	10 8	45 8	133 8	126	2 4
38	90	8	1	11	9	6 12	5 12	34 12	124 12	118	1 12
39	90	6	3	11	11	9 8	8 8	39 8	129 8	120	1 15
40	91	7	5	12	9	6 6	8 6	41 6	132 6	126	2 1
41	84	10	11	10	9	8 8	6 8	46 8	130 8	122	2 5
Totals	3650	299	230	435	400	289 3	336 3	1700 3	5350 3	5061	84 9½
Means, and Average Weekly Gain per Head during each Period.	Mean per Head. lbs. oz. 91 4	lb. ozs. 1 14	lb. ozs. 1 7	lbs. ozs. 2 11½	lbs. ozs. 2 8	Mean per Head. lbs. ozs. 7 3½	lbs. ozs. 2 1½	Mean per Head. lbs. ozs. 42 8	Mean per Head. lbs. ozs. 133 12	Mean per Head. lbs. ozs. 126 8	lbs. oz. 2 1¼

A glance at these Tables shows very great irregularity in the *apparent* rate of increase of the same sheep during different periods, and also of different sheep during one and the same period. This general result we have shown to be very marked in all our feeding experiments. The variation in the total increase per head, among each lot, is also very great; but this irregularity, from whatever cause, is obviously much greater among the Leicesters than the cross-breds. It may be due to the decidedly greater irregularity in weight of the Leicester lambs when first put up; but whether this variableness in rate of increase is really more usual among the lambs of the pure breed than of the cross-breds, or whether it is only due in the present instance to the Leicesters having been drawn from several flocks, and the cross-breds carefully selected from one, we have not the means of deciding. At any rate however, in the case of our experiment, a given weight of either of the cross-bred lots gave a greater average proportion of increase than the Leicesters.

The variation in *average weekly increase per head*, is seen to be—among the 40 Leicesters, from 1 lb. 3 ozs. to 3 lbs. 5 ozs.; among the 40 cross-bred wethers, from 1 lb. 11 ozs. to 2 lbs. 13 ozs.; and among the 40 cross-bred ewes, from 1 lb. 7 ozs. to 3 lbs. That the state of the weather was not without some influence upon the variable rate of increase throughout the different monthly periods, would appear from the fact, that *all the three lots* gave a considerably less amount of increase during the second period—the unusually cold month of January—than at any other time.

These few observations upon the three Tables which show the detailed progress of each sheep, are sufficient again to show the absolute necessity of operating upon large numbers of animals, and extending our experiments over a considerable period of time, if we would attempt to draw trustworthy conclusions from comparative feeding experiments.

In the six following Tables are given, for each lot of sheep respectively (Leicesters, cross-bred wethers, and cross-bred ewes):—

In Table IV. The *total foods* consumed, and *total increase* in live-weight produced, by each lot of 40 sheep, between each weighing (monthly periods).

In Table V. The quantities of the foods consumed during each separate period, and the total period of the experiment, to produce 100 *lbs. increase* in live weight.

In Table VI. The amounts of foods consumed *per head weekly.*

In Table VII. The amounts of the foods consumed *per* 100 *lbs. live weight weekly.*

In Table VIII. The average *increase in weight* per head weekly.

In Table IX. The average increase *upon each* 100 *lbs. live-weight weekly.*

Table IV.

Description and Quantities of Food consumed, and Increase produced, by each lot of Sheep between each interval of weighing (monthly periods). Quantities given in lbs.

Periods.	Length of Time in Weeks.	Oilcake.			Clover Hay.			Swedes.			Increase in Live Weight.		
		Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
From December 2nd to December 30th	4	896	896	840	896	896	840	11,223	10,957	10,609	300	350	299
,, December 30th to January 27th	4	896	896	840	896	896	840	10,345	10,169	9,637	140	276	230
,, January 27th to February 24th	4	896	896	840	896	896	840	12,890	12,595	12,172	497	383	435
,, February 24th to March 24th	4	896	896	840	896	896	840	16,009	15,939	14,662	450	479	400
,, March 24th to April 21st	4	1,120	1,120	1,120	896	896	896	16,584	16,650	15,330	395¾	292	336
Total consumption and increase of 40 each of Leicesters, Cross-bred Wethers, and Cross-bred Ewes	20	4,704	4,704	4,480	4,480	4,480	4,256	67,051	66,310	62,410	1,782¾	1,780	1,700
Average Food consumed and Increase produced by each lot of Sheep (of 40 each) in 4 weeks	–	940¾	940¾	896	896	896	851¼	13,410	13,262	12,482	356½	356	340

Table V.

Quantities of Food consumed during each separate period, and the total period of the experiment, to *produce* 100 *lbs. Increase in Live Weight.* Quantities given in lbs. and ozs.

Periods.	Time in Weeks.	Oilcake.			Clover Hay.			Swedes.		
		Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
From December 2nd to December 30th	4	298 10	256 0	280 15	298 10	256 0	280 15	3,741	3,130	3,548
,, December 30th to January 27th	4	640 0	324 10	365 3	640 0	324 10	365 3	7,389	3,484	4,190
,, January 27th to February 24th	4	180 4	233 15	193 1	180 4	233 15	193 1	2,593	3,288	2,798
,, February 24th to March 24th	4	199 2	187 0	210 0	199 2	187 0	210 0	3,557	3,327	3,665
,, March 24th to April 21st	4	282 15	383 6	333 2	226 6	306 11	266 8	4,189	5,699	4,560
Average for the total period of the experiment	20	263 13¾	264 4½	263 8¼	251 4¼	251 10¼	250 5½	3,761	3,725½	3,671

TABLE VI.

Average Weekly Consumption of Food, *per Head*, during each separate period, and the total period of the experiment. Quantities in lbs. and ozs.

PERIODS.	Time in Weeks.	Oilcake.			Clover Hay.			Swedes.		
		Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
From December 2nd to December 30th	4	5 9½	5 9½	5 4	5 9½	5 9½	5 4	70 2	68 8	66 5
,, December 30th to January 27th	4	5 9½	5 9½	5 4	5 9½	5 9½	5 4	64 10	63 9	60 4
,, January 27th to February 24th	4	5 9½	5 9½	5 4	5 9½	5 9½	5 4	80 9	78 11	76 1
,, February 24th to March 24th	4	5 9½	5 9½	5 4	5 9½	5 9½	5 4	100 1	99 10	91 10
,, March 24th to April 21st	4	7 0	7 0	7 0	5 9½	5 9½	5 9½	103 10	104 1	95 13
Average for the total period of the experiment	20	5 14	5 14	5 9½	5 9½	5 9½	5 5	83 13	82 14	78 0

TABLE VII.

Average Weekly Consumption of Food, *per* 100 *lbs. Live Weight of Animal*, during each separate period, and the total period of the experiment. Quantities in lbs. and ozs.

PERIODS.	Time in Weeks	Oilcake.			Clover Hay.			Swedes.		
		Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
From December 2nd to December 30th	4	5 5½	5 10	5 8½	5 5½	5 10	5 8½	66 12	68 13¼	69 12¼
,, December 30th to January 27th	4	5 1	5 3½	5 2½	5 1	5 3½	5 2½	58 7½	59 3½	59 4¼
,, January 27th to February 24th	4	4 11½	4 13½	4 12¼	4 11½	4 13½	4 12¼	67 15¼	68 2	69 3¼
,, February 24th to March 24th	4	4 4½	4 6¾	4 5¾	4 4½	4 6¾	4 5¾	76 12	78 13¾	76 2
,, March 24th to April 21st	4	4 15½	5 2¼	5 6¼	3 15½	4 1¾	4 5	73 8½	76 8¼	73 15¼
Average for the total period of the experiment	20	4 12	5 0	4 15½	4 8½	4 12¼	4 11½	67 13	70 10	69 5½

TABLE VIII.

Average *Weekly Increase per Head* during each separate Period, and the Total Period of the Experiment.

Quantities in lbs. and ozs.

Periods.	Time in Weeks.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
From December 2 to December 30	4	1 14	2 3	1 14
,, December 30 to January 27	4	0 14	1 11½	1 7
,, January 27 to February 24	4	3 1¾	2 6¼	2 11½
,, February 24 to March 24	4	2 13	3 0	2 8
,, March 24 to April 21	4	2 7½	1 13	2 1½
Average for the Total Period of the Experiment	20	2 3½	2 3½	2 2

TABLE IX.

Average Weekly Increase *per* 100 *lbs. Live-Weight* during each separate Period, and the Total Period of the Experiment.

Quantities in lbs. and ozs.

Periods.	Time in Weeks.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
From December 2 to December 30	4	1 12½	2 3	1 15½
,, December 30 to January 27	4	0 12½	1 9¾	1 6½
,, January 27 to February 24	4	2 9¾	2 1	2 7½
,, February 24 to March 24	4	2 2½	2 5¾	2 1¼
,, March 24 to April 21	4	1 12	1 5½	1 9¾
Average for the Total Period of the Experiment	20	1 12¾	1 14¼	1 14

In Table IV. we have a summary of the actual facts of the consumption of food and the increase in weight, in these feeding experiments; but the comparisons which the results involve will be more easily studied in some of the succeeding Tables. We may notice, however, as indicated in Table IV., that the allowance of oil-cake was increased to each of the three lots, from ¾ lb. to 1 lb. per head per day, during the last four weeks of the experiment. Notwithstanding this there was an increase in the amount of swedes consumed in this period, as compared with the previous ones; throughout which there had been a considerable progressive increase in the rate of consumption of the roots as the season advanced. This increased consumption was probably in part due to the deterioration in the quality of the turnips themselves. But it is doubtless in greater part attributable to the increased requirements of the animals after

losing the protection of their wool, and it may be recalled to mind that the same effect was observable in the experiments with the Cotswolds and the Hampshire and Sussex sheep. The *gross increase* was, however, by no means in proportion to the increased consumption of food during the last four weeks of the experiment.

These remarks on the general progress of the experiment as shown in Table IV. apply pretty equally to the three lots of sheep; though, as is seen in the Table, the increase in the supply of dry food during the last four weeks was, in proportion, rather greater for the cross-bred ewes than for the other two lots of sheep; for it was considered that, taking into calculation their progress, their allowance hitherto had perhaps been scarcely equal to that of the others, in relation to their *mean weight throughout the experiment.*

Table V.—which gives the quantity of each food consumed *to produce* 100 *lbs. increase in live weight*, during each monthly period of the experiment—shows an extraordinary variation in the apparent effect of the food as measured by *increase*, during the different periods. This irregularity is notably greater with the Leicesters than with either of the cross-breds. It is at the same time apparent that there was somewhat of a general tendency among the three lots to greater or less rate of increase, at one and the same period. Thus all three consume a larger amount of food for a given effect during the second period; during the next two periods there was a somewhat better result with all; and during the final month there was again a tendency with all to consume a larger amount of food for a given amount of increase. These observations only tend again to prove the necessity of extending comparative feeding experiments over a considerable length of time; and this will be further seen from the observations which next follow.

Notwithstanding the very great differences which Table V., as just noticed, shows in the amounts of food consumed during one period of the experiment compared with another to produce 100 lbs. of increase—and also the great difference in the amounts consumed by the different lots of sheep for a given effect during each separate period—still, the base line of the table, which gives the *average amount* consumed, to produce 100 lbs. of increase during the *total period* of the experiment, shows, that thus taking the whole course of the experiment, the three lots consumed almost identical amounts of the respective foods, to produce a given weight of increase. The identity of the figures is indeed quite remarkable, in a series of comparative trials on such a scale. Though, if the variations, small as they are, are to be taken as indicating any real difference between the lots, it

would seem, that the *cross-bred ewes* have given somewhat the best account of the food which they have consumed.

Table VI. shows the amounts of the foods consumed *per head per week*. But as the allowance of the *dry* foods (until it was increased during the last period of the experiment) was allotted in fixed quantity in relation to the weights of the animals at the beginning, the variation in their amounts during the first four periods indicates nothing more than the variation in the original weights of the different lots of sheep. However, we see, that the average consumption per head of *swedes*, which were given *ad libitum*, varies among the three lots as nearly as possible in the same ratio as that of the other foods; and hence, it would appear, that in relation to the weights of the animals, the requirements of food are the same for the three lots. This point is better seen in Table VII.

In Table VII., we have the average weekly consumption of food *per* 100 *lbs. live weight of animal*, instead of per head. The figures in this Table show that the cross-bred wethers consumed rather the most of each of the three foods in relation to their average weight throughout the experiment. The cross-bred ewes were the next in order in this respect, whilst the Leicesters consumed the least. Since, however, we have seen in Table V. that the cross-bred ewes gave if anything a somewhat better rate of increase in relation to food consumed than the Leicesters, the slightly larger consumption by them in relation to weight within a given time is at any rate no disadvantage.

In Table VIII. we have the *average weekly increase per head*. With great fluctuation in this respect between the three lots at every separate period of weighing, there is comparatively little difference taking the average of the whole period. We would here, however, fix attention upon the fact that in these experiments with 40 sheep of good quality in each lot, fed under cover—the experiment extending over 20 weeks, and with food certainly superior to that which is frequently given to fatting sheep—we have with neither lot an average weekly gain in weight of 2½ lbs. per head. We refer to this point particularly, as a further proof of the over-estimations which are frequently founded upon experiments conducted on a comparatively limited scale.

In Table IX. we have the average weekly gain *per cent.*, that is, *per* 100*lbs. live weight of animal*, instead of *per head*. We see here, that with neither lot of sheep is there an average gain of 2 per cent. per week upon the live weight. Both the lots of cross-breds gave a somewhat higher rate of increase, in proportion to their weight, than the Leicesters: the amounts being, for the cross-bred wethers 1 lb. 14¼ ozs.; for the cross-bred ewes 1 lb. 14 ozs.; and for the Leicesters 1 lb. 12¾ ozs.

Upon the whole, then, comparing the new Leicester sheep with the cross between the Leicester ram and the Southdown ewe, when fed under cover upon a liberal supply of good food, the results, so far as the relation of gross increase to food consumed is concerned, are very nearly identical; but if there be a difference sufficiently marked in these experiments, it is certainly in several points somewhat in favour of the *cross-breds;* whilst, among the latter, the *ewes* would seem to make mutton rather faster than the wethers.

The circumstances of these experiments were certainly all in favour of the requirements of the pure Leicester breed; or rather the hardier qualities of the cross with the Southdown were not put to the test. Nine of the Leicester lambs purchased were, however, wintered with the ordinary flock on the farm; and it should be remarked that they none of them stood the winter so well as the main flock—a cross between the Hampshire and Sussex Down: several of these 9 Leicesters indeed died; and none of them did well. It is to be regretted that an equal number of the cross-bred wethers and ewes (Leicester and Southdown) were not at command to turn out by the side of the pure Leicesters, two only of the cross-breds being wintered in the field; these two, however, stood the winter well. Such a result is, in the general, much what we should have expected. But it is only fair to say that the 9 Leicesters which were turned out were the worst of the 50 lambs purchased; and it is not improbable, therefore, that they were somewhat bad representatives of their race.

The next point of comparison is as to the wool; the amounts of which are given in Table X., which follows.

TABLE X.

	Average Wool per Head.	Proportion of Wool in 100 lbs. Live Weight of Animal at the time of being Shorn.
	lbs. ozs.	
Leicesters shorn .. .. April 7, 1853	8 $2\frac{1}{4}$	5·58
Cross-bred Wethers shorn .. ,,	6 7	4·60
Cross-bred Ewes shorn .. .. ,,	7 $3\frac{1}{2}$	5·40

The three lots of sheep were shorn on April 7th, 1853, having been washed a week previously. The average yield of wool *per head* is seen to be 8 lbs. $2\frac{1}{4}$ ozs. for the Leicesters, 7 lbs. $3\frac{1}{2}$ ozs. for the cross-bred ewes, and 6 lbs. 7 ozs. for the

cross-bred wethers. The average for the cross-breds is therefore about 6 lbs. 13 ozs. per head. The Leicesters therefore have given an average of nearly $1\frac{1}{4}$ lb. more *weight* of wool per head than the cross-breds. The respective money values of the different descriptions of wool will be referred to further on.

The second column of the Table (X.) shows that the pure Leicesters and cross-bred ewes each gave about $5\frac{1}{2}$ *per cent. of their weight* of wool at the time of shearing; and the cross-bred *wether* only about $4\frac{1}{2}$ per cent.

As in the case of the breeds previously reported upon, some of these Leicesters and cross-breds were killed at home, and the weights of the carcasses and of the different parts of the offal taken; some were sold alive; and a few kept to be fed till the Christmas following. The main experiments with the Hampshire and Sussex Downs had been extended over 26 weeks; that with the Cotswolds only 20 weeks, when some of them were found to be already even too fat. These Leicesters and cross-breds also were kept on fattening food for only 20 weeks. But, as appeared by the results, neither of these three lots was as well ripened as had been the Hampshire and Sussex Downs and the Cotswolds.

Of each of the lots of 40 sheep under consideration, 16 were killed at home, and their carcasses sent to Newgate market; 16 were sold alive at Smithfield; and 8 retained for further fattening.

The 16 killed at home were—

The 4 of *largest* increase,
The 4 of *smallest* increase, and
The 8 of *medium* increase.

The 16 sent to Smithfield alive were, respectively—

The 8 of the *next largest*, and
The 8 of the *next smallest* increase—to the lots of 4 each above mentioned.

The remaining 8 of each lot were fed till Christmas.

The following Table (XI.) — giving the mean increase per head, average weight of wool per head, and average weights of the sheep at the commencement and at the conclusion of the experiment—shows how far the method of allotment adopted brought together pretty average qualities within each lot in these respects. The only point deserving any notice is, that the sheep allotted for feeding until Christmas appear to have been on an average somewhat lighter throughout than the other lots.

TABLE XI.

	Average Increase per Head, including Wool.						Average Wool per Head (Shorn April 7).					
	Leicesters.		Cross-bred Wethers.		Cross-bred Ewes.		Leicesters.		Cross-bred Wethers.		Cross-bred Ewes.	
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
Mean of 16 killed at home	44	8¼	44	14½	42	10¼	8	3	6	9½	6	15¼
Mean of 16 sold alive	44	5	44	9¼	42	4	8	1	6	10¼	7	8¼
Mean of 8 to be fed till Christmas	44	11	43	8½	42	11¾	8	3	5	10½	7	3¾
Mean of 40 Sheep ..	44	9	44	8	42	8	8	2¼	6	7	7	3½

	Average Original Weight, Dec. 2, 1852.						Average Final Weight, April 21, 1853 (without Wool).					
	Leicesters.		Cross-bred Wethers.		Cross-bred Ewes.		Leicesters.		Cross-bred Wethers.		Cross-bred Ewes.	
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
Mean of 16 killed at home	102	2	95	8	91	1	138	7	133	12¼	126	12
Mean of 16 sold alive	102	5	96	2	91	14	138	13	134	1	126	10
Mean of 8 to be fed till Christmas	97	12	92	4	90	6	134	4	130	2	125	12
Mean of 40 Sheep ..	101	5	95	1½	91	4	137	12	133	3	126	8

The following Table (XII.) gives the *dead-weights*, &c., of the sheep killed at home, by the side of some particulars of them whilst alive. And we have, especially in the *summary* given at the foot of the Table, the means of comparing the state of maturity and quality as meat-producers, both of the lots of different rates of increase within each breed, and of the average of the whole 16 of each killed. (*See* pp. 62, 63.)

The construction of this Table (XII.) is designed to show the connection between the tendency to rapid increase and other particulars of the sheep whilst alive, on the one hand, and those ascertained on killing them, on the other. The first observation that occurs on looking at the Table is that which has been made in reference to other breeds—viz., that there is among animals of pretty equal increase great diversity in other qualities. This is not, however, either equally marked with these three lots of sheep, or in relation to all the qualities indicated in the Table.

Thus, in each of the three lots, the animals brought together as having increased nearly equally show a considerable diversity in amount of wool, in original weight, in final weight; also, pretty generally, in actual carcass-weight, in proportion of

carcass-weight to live-weight, and particularly in the percentage of loose or inside fat.

In the summary at the bottom of the Table we have again shown, that which has already been otherwise indicated, the much greater irregularity in the rate of increase among the Leicesters than among either of the cross-bred lots. Thus, among the Leicesters the average gain of the 4 of *smallest* increase is less than half that of the 4 of *greatest* increase; the numbers being, for the former 28 lbs. per head, and for the latter $61\frac{3}{4}$ lbs. The variation among the cross-breds is much less. Among the *wethers* the average gain of the 4 of smallest increase was $35\frac{1}{4}$ lbs., and that of the 4 of largest increase $55\frac{1}{2}$ lbs.; and among the *ewes*, that of the 4 of smallest increase was $32\frac{3}{4}$ lbs., and of the 4 of largest increase $52\frac{3}{4}$ lbs. The bottom lines of these columns of increase show, however, that although the differences were much greater within one lot than another, yet the *average* increase per head of each lot of 40 sheep was very nearly identical for the Leicesters, cross-bred wethers, and cross-bred ewes. It was, however, for the ewes about 2 lbs. less than for either of the other lots.

With, as already noticed, great diversity in the amount of *wool* yielded by sheep of nearly equal increase, we have still, with all three lots, somewhat more wool with the sheep of largest increase than with those of either smallest or medium rate of increase. The summary shows too, as we should expect, that in each of the allotments, according to increase, the Leicesters give more wool than the cross-breds; and, among the cross-breds, the ewes give upon the whole more wool than the wethers.

The actual carcass or dead weight (calculated in stones of 8 lbs.) varies among the 16 Leicesters killed from little more than $6\frac{1}{4}$ stones to nearly $12\frac{1}{2}$ stones; among the 16 cross-bred wethers it ranges only from nearly 8 stones to nearly $10\frac{1}{2}$ stones; and among the slaughtered cross-bred ewes the variation is from nearly $7\frac{3}{4}$ stones to $9\frac{3}{4}$ stones. With this great variation in the amount of meat produced per head, and particularly among the Leicesters, the average of the whole 16 of each lot killed agrees more nearly than we should have expected. Thus the average yield of mutton of the 16 Leicesters killed is about $9\frac{1}{2}$ stones; that of the cross-bred wethers $9\frac{1}{4}$ stones; and of the cross-bred ewes nearly $8\frac{3}{4}$ stones. The cross-breds have therefore given, on the average, nearly as much meat per head as the Leicesters. As already intimated, however, all three lots would have been somewhat better for another month of feeding; which, we may calculate, would have given at that stage of the fattening process an average of nearly a stone per head more carcass-weight for each of the three lots of sheep.

Table XII.

Sheep. Nos.			Weights Alive. Increase per Head, including Wool, in 20 Weeks.			Wool per Head, Shorn April 7.			Original Weight, December 2nd, 1852.			Final Live Weight without Wool. Not Fasted.		
Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
			lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
5	3	35	66 4	56 12	59 14	10 4	8 12	7 14	119 0	88 0	84 0	175 0	136 0	136 0
14	15	6	62 12	56 0	51 6	8 12	7 0	7 6	121 0	93 0	91 0	175 0	142 0	135 0
11	17	9	62 0	55 10	50 14	10 0	7 10	6 14	117 0	99 0	95 0	169 0	147 0	139 0
8	12	1	56 0	53 12	49 4	10 0	6 12	7 4	108 0	102 0	91 0	154 0	149 0	133 0
Mean of the 4 largest .			61 12	55 8½	52 13½	9 12	7 8½	7 5½	116 4	95 8	90 4	168 4	143 8	135 12
7	36	38	31 0	36 13	34 12	6 0	5 13	6 12	96 0	91 0	90 0	121 0	122 0	118 0
23	30	21	31 9	36 6	33 8	8 9	5 6	5 8	92 0	88 0	91 0	115 0	119 0	119 0
32	8	14	25 12	34 8	33 6	9 12	7 8	6 6	93 0	100 0	92 0	109 0	127 0	119 0
35	35	12	23 11	33 7	29 7	6 11	6 7	6 7	84 0	98 0	89 0	101 0	125 0	112 0
Mean of the 4 smallest			28 0	35 4½	32 12¼	7 12	6 4½	6 4½	91 4	94 4	90 8	111 8	123 4	117 0
12	6	19	46 3	45 12	43 10	8 3	4 12	7 10	114 0	95 0	86 0	152 0	136 0	122 0
28	26	23	45 14	45 4	43 8	6 14	5 4	6 8	100 0	102 0	98 0	139 0	142 0	135 0
36	33	4	45 7	44 12	43 8	8 7	6 12	7 8	89 0	88 0	86 0	126 0	126 0	122 0
17	20	10	45 5	44 9	42 10	8 3	6 9	5 10	105 0	98 0	98 0	142 0	136 0	135 0
3	11	15	44 2	44 8	42 3	9 2	5 8	7 3	105 0	101 0	87 0	140 0	140 0	122 0
10	5	26	43 4	44 5	41 12	7 4	8 5	7 12	95 0	89 0	96 0	131 0	125 0	130 0
18	19	40	41 10	43 13	41 6	6 10	6 13	6 6	105 0	96 0	91 0	140 0	133 0	126 0
40	14	2	41 8	42 8	41 4	6 8	6 8	8 4	91 0	100 0	92 0	126 0	136 0	125 0
Mean of the 8 medium			44 2½	44 7	42 7½	7 10¼	6 5	7 1½	100 8	96 2	91 12	137 0	134 4	127 2

Summary.

Mean of the 4 largest .	61 12	55 8½	52 13½	9 12	7 8½	7 5½	116 4	95 8	90 4	168 4	143 8	135 12
Mean of the 4 smallest	28 0	35 4½	32 12¼	7 12	6 4½	6 4½	91 4	94 4	90 8	111 8	123 4	117 0
Mean of the 8 medium	44 2½	44 7	42 7½	7 10¼	6 5	7 1½	100 8	96 2	91 12	137 0	134 4	127 2
Mean of 16 killed . .	44 8¼	44 14½	42 10¼	8 3	6 9½	6 15¼	102 2	95 8	91 1	138 7	133 12½	126 1[illegible]
Mean of the 40 Sheep .	44 9	44 8	42 8	8 2¼	6 7	7 3½	101 5	95 1½	91 4	137 12	133 3	126 [illegible]

Table XII.

Weights Alive.			Weights Dead.											
Final Live Weight without Wool. Fasted.			Carcass, 28 to 36 hours after killing.			Proportion of Cold Carcass in 100 Unfasted Weight.			Proportion of Cold Carcass in 100 Fasted Weight.			Proportion of Loose or Inside Fat in 100 Fasted Weight, including Wool.		
eicesters	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-Bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.	Leicesters.	Cross-bred Wethers.	Cross-bred Ewes.
s. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.									
50 0	126 0	122 0	97 14	76 1	75 4	55·9	55·9	55·3	61·2	60·4	61·7	4·80	4·60	5·92
50 0	131 0	122 0	99 15	83 13	76 1	57·1	59·0	56·4	62·5	64·0	62·4	5·19	6·42	5·05
5 0	135 0	125 0	94 5	81 8	76 9	55·8	55·4	55·1	60·8	60·4	61·2	5·56	4·08	6·94
0 0	135 0	118 0	86 10	82 6	70 10	56·2	55·3	53·1	61·9	61·0	59·8	4·46	5·25	5·06
3 12	131 12	121 12	94 11	80 15	74 10	56·2	56·4	55·0	61·6	61·4	61·3	5·00	5·09	5·74
0 0	110 0	106 0	65 5	66 11	63 14	54·0	54·7	54·1	59·4	60·6	60·2	5 07	4·31	6·18
4 0	106 0	107 0	57 10	63 4	66 0	50·1	53·2	55·5	55·4	59·7	61·7	3·21	4·71	7·19
0	115 0	108 0	58 6	64 10	66 11	53·6	50·9	56·0	58·4	56·2	61·7	3·03	5·69	4·73
2 0	116 0	102 0	50 7	67 11	61 8	49·9	54·2	54·9	54·8	58·4	60·3	3·07	6·10	4·87
8	111 12	105 12	57 15	65 9	64 8¼	51·9	53·2	55·1	57·0	58·7	61·0	3·59	5·20	5·74
0	122 0	112 0	88 11	77 9	64 5	58·3	57·0	52·7	63·3	63·6	57·4	4·64	6·19	5·93
0	134 0	123 0	77 14	79 5	74 6	56·0	55·9	55·1	61·8	59·2	60·5	4·73	7·25	5·48
0	114 0	111 0	63 14	70 12	66 6	50·7	56·1	54·4	56·5	62·1	59·8	3·86	5·64	5·88
0	127 0	124 0	79 15	77 10	78 4	56·3	57·1	58·0	61·5	61·1	63·1	6·74	6·01	6·18
0	126 0	110 0	78 2	79 9	67 5	55·8	56·8	55·2	60·1	63·1	61·2	4·83	4·77	5·73
0	115 0	118 0	71 7	67 0	69 13	54·5	53·6	53·7	62·1	58·3	59·2	5·03	3·88	6·34
0	126 0	116 0	79 5	71 8	71 13	56·6	53·8	57·0	62·0	56·7	61·9	3·74	4·58	5·59
0	120 0	112 0	69 2	75 1	70 1	54·9	55·2	56·0	59·1	62·6	62·5	5·62	6·10	5·56
1 14	123 0	115 12	76 0¾	74 12¾	70 4½	55·4	55·7	55·3	60·8	60·8	60·7	4·90	5·55	5·84

Summary.

12	131 12	121 12	94 11	80 15	74 10	56·2	56·4	55·0	61·6	61·4	61·3	5·00	5·09	5·74
8	111 12	105 12	57 15	65 9	64 8¼	51·9	53·2	55·1	57·0	58·7	61·0	3·59	5·20	5·74
14	123 0	115 12	76 0¾	74 12¾	70 4½	55·4	55·7	55·3	60·8	60·8	60·7	4·90	5·55	5·84
4	122 6	114 12	76 2¾	74 0¼	69 14¾	54·7	55·3	55·2	60·0	60·5	60·9	4·60	5·35	5·79

From the circumstance, too, of the sheep being rather *under* fattened, the *proportion* of carcass to live weight is generally somewhat small among these three lots of sheep. In the Table the proportion of dead or carcass weight, calculated both to the *un*-fasted and the *fasted* live-weight, is given. But as in the *un*fasted condition the animals are likely to retain much more variable amounts of unassimilated food—affecting therefore considerably the weight of the stomach and intestines—the percentage of carcass in the *fasted* weight gives us the safest ground of comparison. Among the sheep of largest increase we see a slight tendency to a greater percentage of carcass among the Leicesters than the cross-breds. Among those of the smallest increase, on the other hand, the difference is in favour of the cross-breds; and it is here also more marked than with the lots of largest increase. Among these lots of smallest increase, too, the cross-bred *ewes* give a markedly better proportion of carcass than the wethers. The mean percentage relation of carcass to fasted weight, among the sheep of *medium* rate of increase, is curiously identical for the three descriptions of sheep. It is also, as seen in the bottom line of the summary, very nearly identical for the three lots, taking the mean of the whole 16 killed in each case. It is, however, slightly better with the cross-breds than with the Leicesters; and, among the former, slightly better with the ewes than with the wethers.

Considering the general points of contrast between the Leicester and Southdown sheep—and especially the admitted greater tendency of the former to fatten in carcass and come early to maturity—we should perhaps have anticipated a better proportion of *dead* or *carcass* to live-weight among the Leicesters than the cross-breds; and more especially so under the circumstances of our experiment, in which its perhaps somewhat premature termination would, we should suppose, have been more adverse to the cross-bred than to the generally earlier ripening pure Leicesters. We leave it to the reader to decide whether the results, as the figures show them, should be considered true indications of the comparative qualities of pure Leicesters and cross-breds; or whether the obviously greater irregularity among the sheep composing our flock of the pure breed should be taken as evidence of a less successful selection for the purposes of our experiment in their case than in that of the cross-breds.

The only further point to notice, relating to the *dead-weights*, is as to the proportion of *loose* or *inside fat*. The general distinctive character of Leicesters and Downs is pretty well borne out by the figures under this head. Thus, notwithstanding the considerable variation in the amounts yielded by *individuals* within each breed, there is an obvious tendency in the cross-

breds—both among those of largest, of smallest, and of medium increase—to give a greater amount of "loose," "inside," or "offal" fat than the Leicesters. The amount is obviously greater too, among the cross-bred *ewes* than the cross-bred wethers. Comparing on this point the cross-breds, as a whole, with the Leicesters, we should, as already said, have anticipated a larger proportion of inside fat among the former than the latter. But as we have with this, at the same time, a general tendency to better proportion of *carcass-weight* also among the cross-breds, it would seem that they had perhaps, in point of fact, made, up to the time of killing, nearly as large a proportion, both of carcass and of inside—that is, of total fat—and were therefore in reality as fully "ripened," as the Leicesters, and this result we scarcely should have looked for.

Upon the whole, then, the result indicated by a consideration of this Table (XII.) of the particulars of the live and dead weights of those of the sheep killed at home is, that the Leicesters, although they have given, in *individual cases*, a very large carcass-weight, have, on the average, given not more than half a stone per head above the cross-breds; that the cross-breds, and especially the ewes, have given a somewhat better proportion of carcass-weight to live-weight; and more obviously still, the cross-breds, and again the ewes in particular, have given the largest proportion of inside or loose fat.

In the Tables which next follow are given the particulars of sale of the three lots of sheep.

Table XIII.

Particulars of Sale of the Leicesters.

				Weight.		Produce of Sale.		
		s.	d.	lbs.	oz.	£.	s.	d.
8 Sheep—4 of Largest, and 4 of Smallest Increase..	6 Carcasses, at	4	2 per stone	407	0	10	11	11
	2 ,,	4	0 ,,	188	0	4	14	0
8 medium Sheep	1 ,,	4	1 ,,	69	0	1	15	2
	7 ,,	4	2 ,,	525	0	13	13	3
	Wool	1	3 per lb.	131	2	8	3	11
	Skins	0	9 each	..		0	12	0
	Heads & Plucks	1	3 ,,	..		1	0	0
	Loose Fat	0	$3\frac{3}{4}$ per lb.	100	8	1	11	5
						42	1	8
Killing, 8*d*. per head; Selling and Charges at Newgate Market, 14*s*. 10*d*.				..		1	5	6
Net for 16 Sheep sold dead				..		40	16	2
Net per head				..		2	11	0

TABLE XIII.—*continued.*

	Weight.		Produce of Sale.		
	lbs.	oz.	£.	s.	d.
16 Sheep sold alive, viz. .. .. {8 at 40s. per head	..		16	0	0
{8 at 38*s*. ,,	..		15	4	0
Wool at 1*s*. 3*d*. per lb.	128	15	8	1	2½
			39	5	2½
Commission and Selling	..		0	10	8
Net for 16 Sheep sold alive	..		38	14	6½
Net per head	..		2	8	4¾
SUMMARY.					
16 Sheep sold dead (including Wool)	..		40	16	2
16 Sheep sold alive (including Wool)	..		38	14	6½
8 Sheep not sold, estimated at the price of those sold alive	..		19	7	3¼
			98	17	11¾
Average per head (including Wool)	..		2	9	5¼

TABLE XIV.

Particulars of Sale of the Cross-bred Wethers.

		s.	d.	Weight. lbs.	oz.	Produce of Sale. £.	s.	d.
8 Sheep—4 of Largest, and 4 of Smallest Increase	Carcasses at ..	4	2 per stone	569	0	14	16	3
8 medium Sheep	,,	4	2 ,,	579	0	15	1	5
	Wool	1	5 per lb.	105	11	7	9	8¾
	Skins	0	9 each	..		0	12	0
	Heads & Plucks	1	3 ,,	..		1	0	0
	Loose Fat	0	3¾ per lb.	110	12	1	14	7½
						40	14	0¼
Killing, 8*d*. per head; Selling and Charges at Newgate Market, 14*s*. 2*d*.				..		1	4	10
Net for 16 Sheep sold dead				..		39	9	2¼
Net per head..				..		2	9	3¾
16 Sheep sold alive at 41*s*. per head				..		32	16	0
Wool at 1*s*. 5*d*. per lb.				106	3	7	10	5
						40	6	5
Commission and Selling				..		0	10	8
Net for 16 Sheep sold alive				..		39	15	9
Net per head..				..		2	9	8¾

TABLE XIV.—*continued.*

	Weight.	Produce of Sale.
SUMMARY.	lbs. oz.	£. s. d.
16 Sheep sold dead (including Wool)	..	32 9 $2\frac{1}{4}$
16 Sheep sold alive (including Wool)	..	39 15 9
8 Sheep not sold, estimated at the price of those sold alive	..	19 17 $10\frac{1}{2}$
		99 2 $9\frac{3}{4}$
Average per head (including Wool)	..	2 9 $6\frac{3}{4}$

TABLE XV.

Particulars of Sale of the Cross-bred Ewes.

		s. d.	Weight. lbs. oz.	Produce of Sale. £. s. d.
8 Sheep—4 of Largest, and 4 of Smallest Increase..	2 Carcasses at	4 4 per stone	125 0	3 7 8
	6 ,,	4 2 ,,	416 0	10 16 8
8 Medium Sheep	2 ,,	4 1 ,,	135 0	3 8 10
	6 ,,	4 2 ,,	410 0	10 13 6
	Wool	1 5 per lb.	114 3	8 1 $9\frac{1}{4}$
	Skins	0 9 each	..	0 12 0
	Heads & Plucks	1 3 ,,	..	1 0 0
	Loose Fat	0 $3\frac{3}{4}$ per lb.	112 12	1 15 3
				39 15 $8\frac{1}{4}$
Killing, 8*d*. per head; Selling and Charges at Newgate Market, 14*s*.			..	1 4 8
Net for 16 Sheep sold dead			..	38 11 $0\frac{1}{4}$
Net per head			..	2 8 $2\frac{1}{4}$
16 Sheep sold alive at 38*s*. per head			..	30 8 0
Wool at 1*s*. 5*d*. per lb.			120 1	8 10 1
				38 18 1
Commission and Selling			..	0 10 8
Net for 16 Sheep sold alive			..	38 7 5
Net per head			..	2 7 $11\frac{1}{2}$

	Weight.	Produce of Sale.
SUMMARY.		
16 Sheep sold dead (including Wool)	..	38 11 $0\frac{1}{4}$
16 Sheep sold alive (including Wool)	..	38 7 5
8 Sheep not sold, estimated at the price of those sold alive	..	19 3 $8\frac{1}{2}$
		96 2 $1\frac{3}{4}$
Average per head (including Wool)	..	2 8 $0\frac{1}{2}$

The carcasses of the 16 of each lot killed at home were sold at Newgate Market on April 25th and 27th, and the offal and loose fat were sold at home. The 16 of each sold alive were sent to Smithfield on April 25th. The 8 of each kept to be fed till Christmas are calculated at the prices obtained per head for those sold alive. The wool was not sold, but was valued, according to the prices then ruling, at 1*s.* 5*d.* per lb. for the cross-breds, and 1*s.* 3*d.* per lb. for the Leicesters. Both mutton and wool were exceedingly dear at the time of these sales, compared with those of the Hampshires, Sussex Downs, and Cotswolds; but the Leicester and cross-bred lambs were also purchased at a very high price.

The prices per stone (of 8 lbs.) of the sheep sold dead ranged, for the Leicesters, from 4*s.* to 4*s.* 2*d.*, giving an average of 4*s.* 1½*d.* The cross-bred wether carcasses all sold at 4*s.* 2*d.* per stone; the ewes at from 4*s.* 1*d.* to 4*s.* 4*d.*, giving an average of about 4*s.* 2*d.* The difference of price in favour of the cross-bred carcasses is only, therefore, about ½*d.* per stone of 8 lbs., which is certainly less than we should have expected. This was probably due to the rather under-fattened condition of the animals, which would not perhaps have the tendency to depreciate the price per stone of the Leicesters so much as that of the cross-breds, which latter particularly would certainly have been improved if they had had a little more time. The wool of the Leicester sheep amounted to about 10*s.* 2*d.* per head; that of the cross-bred wethers to 9*s.* 4½*d.*; and of the cross-bred ewes to 10*s.* 4½*d.* These prices will give an average of somewhat less than 6*d.* per head in favour of the Leicesters over the cross-breds on the score of wool. In *loose fat* the Leicesters yielded about 3*d.* per head less than the cross-breds.

Of the 16 sheep of each lot sold alive, the prices per head of the Leicesters ranged from 38*s.* to 40*s.*, giving an average of 39*s.* per head. The cross-bred wethers sold for 41*s.*, and the cross-bred ewes for 38*s.*, giving an average of 39*s.* 6*d.* per head.

The general result as to price is, that, of the sheep sold dead, the Leicesters gave, including wool and offal, an average of about 2*l.* 11*s.*; the cross-bred wethers 2*l.* 9*s.* 4*d.*, and the cross-bred ewes about 2*l.* 8*s.* 2*d.* per head.

Of the sheep sold alive (including wool), the Leicesters averaged 2*l.* 8*s.* 5*d.*; the cross-bred wethers, 2*l.* 9*s.* 9*d.*; the cross-bred ewes 2*l.* 8*s.*: or an average per head for the cross-breds of about 2*l.* 8*s.* 10½*d.*

Of the sheep sold dead, therefore, the price per head is about 2*s.* in favour of the Leicesters; and of those sold alive about 6*d.* in favour of the cross-breds. The ewe mutton, both alive and dead, fetched rather less than the wether.

Taking the average of the 40 sold (the 8 not sold being esti-

mated at the prices of those sold alive), the produce per head is, for the Leicesters, 2*l.* 9*s.* 5¼*d.*; for the cross-bred wethers, 2*l.* 9*s.* 6¾*d.*; for the cross-bred ewes, 2*l.* 8*s.* 0½*d.*: or an average for the 80 cross-breds—mixed ewes and wethers—of about 2*l.* 8*s.* 9½*d.*; that is, on the whole, about 8*d.* per head less for the cross-breds than for the Leicesters.

In giving a balance-sheet of these experiments, we must reiterate a protest against any great reliance being placed on money calculations of this kind, in which the rates both of purchase and sale are subject to so many fluctuating circumstances. Such a *balance*-sheet may be of some use to those who will accept it with due qualification; but, even then, not as a means of measuring the profit or loss of the feeding process, which involve so many other considerations than the mere cost of the store animals and their food on the one hand, and their produce of sale on the other. It is only given then as a means of aiding a *comparison* between the particular lots under consideration, and even then it must be borne in mind that, in going into the market to procure animals pure as to breed, and to a certain extent even and above average quality, something like a fancy price must be paid for the stores, which will vary according to the trouble that has been taken and the number of flocks that have been visited in making the selection. Given then with these cautions, the following are balance-sheets for the Leicesters, cross-bred wethers, and cross-bred ewes respectively.

TABLE XVI.

Balance Account of the Leicesters.

	£. s. d.	£. s. d.
Cost of 40 Leicester Lambs at 36*s.* 6*d.* per head	..	73 0 9
They consumed of purchased food:—		
4704 lbs. Oilcake at 8*l.* per ton	16 16 0	..
4480 lbs. Clover Hay at 4*l.* 10*s.* per ton	9 0 0	..
Total purchased food	..	25 16 9
		98 16 0
40 Fat Leicester Sheep and Wool sold, April, 1853, for	..	98 17 11¾
Difference	..	0 1 11¾

TABLE XVII.

TABLE XVII.

Balance Account of the Cross-bred Wethers.

	£. s. d.	£. s. d.
Cost of 40 Cross-bred Wether Lambs at 34*s.* per head	..	68 0 0
They consumed of purchased food:—		
4704 lbs. Oilcake at 8*l.* per ton	16 16 0	..
4480 lbs. Clover Hay at 4*l.* 10*s.* per ton	9 0 0	..
Total purchased food	..	25 16 0
		93 16 0
40 Fat Cross-bred Wethers and Wool sold, April, 1853, for	..	99 2 9¾
Difference	..	5 6 9¾

TABLE XVIII.

Balance Account of the Cross-bred Ewes.

	£. s. d.	£. s. d.
Cost of 40 Cross-bred Ewe Lambs at 33*s.* per head ..	..	66 0 0
They consumed of purchased food:—		
4480 lbs. Oilcake at 8*l.* per ton	16 0 0	..
4256 lbs. Clover Hay at 4*l.* 10*s.* per ton	8 11 0	..
Total purchased food	..	24 11 0
		90 11 0
40 Fat Cross-bred Ewes and Wool sold, April, 1853, for	..	96 2 1¾
Difference	..	5 11 1¾

The Leicesters, as before stated, cost 35*s.* per head when bought, and, in addition to this, 3*d.* per head per week is charged for their board up to the time of commencing the experiment, which brings them to 36*s.* 6*d.* on December 2nd.

The larger number of the cross-breds were bought in at 32*s.* per head; but others, which arrived some weeks later, cost 33*s.*: charging, as before, 3*d.* per head per week for board, the cross-breds average 33*s.* 6*d.* per head at the commencement of the experiment; but as the mean live-weight of the *wether* stores was about 4 lbs. more than that of the ewes, the former are reckoned as costing 34*s.*, and the latter 33*s.* per head.

On former occasions we have charged the oilcake at 6*l.* 15*s.* per ton, and the clover-hay at 4*l.* per ton: both these, however, were much dearer at the time of this experiment, and they are charged therefore at their market prices at the time, without carriage—viz., the oilcake at 8*l.* per ton, and the clover-hay at 4*l.* 10*s.*

In Table XVI. it is seen that, upon the estimates assumed, the 40 fat Leicester sheep, with their wool, sold for only 2*s.* more than the cost of the lambs, together with that of the oil-cake and clover-chaff; leaving, therefore, the manure of the cake, clover, and turnips to pay for the turnips and attendance, lodging, &c.

Balancing the cross-breds on the same plan, it is seen that the *wethers* give 5*l.* 6*s.* 10*d.*, and the *ewes* 5*l.* 11*s.* 2*d.*, besides their manure, to pay for the turnips, attendance, &c.

This kind of calculation would therefore tell very much in favour of the cross-breds in this particular experiment. But it may be well to observe that a reduction of 2*s.* 6*d.* per head on the price of the Leicester lambs—that is, if we charge them the same as the cross-bred wethers, at 34*s.*, instead of 36*s.* 6*d.*—would bring them to pretty nearly an equality with the other lots. Before, therefore, any reliance can be placed in the comparison between Leicesters and cross-breds which this balance-sheet shows, it should be decided what in practice would, on the average, be the relative cost of Leicester lambs averaging 101 lbs. per head, and of cross-bred wethers weighing 95 lbs. And with a view to a judgment on this point, it may be mentioned that our actual prices on this occasion represent the Leicesters as costing about 4*d.* more per 100 lbs. live weight than the cross-breds. We suppose, therefore, the price paid for the Leicesters to be relatively somewhat too high. The actual prices adopted also represent the cross-bred ewes as worth 3*d.* or 4*d.* more per 100 lbs. live weight than the wethers; and considering their slightly better yield, both of wool and meat, for food consumed, it is perhaps not unfair to estimate the ewe lambs as fully equal in value, weight for weight, to the wethers. Assuming, then, the relative prices of the ewe and wether lambs to have been fair, our balance-sheet shows an advantage of a few shillings on the 40 sheep in favour of the ewes over the wethers, and certainly we did find them to give slightly the best account of the food they consumed.

Upon the whole, then, the general results of this comparative trial between the Leicesters and their cross with the South-Down are:—

That the cross-breds consumed slightly more food, in relation to a given weight of animal, within a given time, than the Leicesters.

That the Leicesters and cross-bred wethers consumed all but identical amounts of food to produce a given amount of increase, and the cross-bred *ewes* rather *less* than either.

That the cross-breds yielded slightly the most increase upon a given weight of animal within a given time.

That the Leicesters gave rather more wool, both per head and per cent. upon their weight, and the cross-bred ewes more than the wethers.

That the fat Leicesters averaged only about 4 lbs. more weight per carcass than the cross-breds.

That the cross-breds gave, within a given time, slightly the highest percentage of dead-weight to live-weight; rather the most loose or inside fat (especially the ewes), and slightly the highest price per stone of mutton.

And finally, when sold dead, the Leicesters,—and when sold alive the mixed cross-bred,—gave slightly the highest average price per head.

With the above observations we conclude the comparison between the Leicesters and cross-breds *alone*, as rapid fatteners on a liberal system of feeding and management; and in the usual 'Tabulated Summary' of the results which next follows (Table XIX.), we include those of the Hampshire and Sussex Downs and Cotswolds. Henceforth, therefore, the whole six lots of sheep will be compared together.

Taking the items of comparative interest somewhat in the order in which they stand in this *Tabulated Summary*, it is seen that of the six lots that have been experimented upon, the Cotswolds give by far the largest average weekly increase per head; indeed, about half as much more than either the Sussex, Leicester, or cross-bred sheep, and nearly one-fourth more than the Hampshires, which are the second in order of *rate of increase per head per week*.

The increase *per* 100 *lbs. live weight per week*, as given in the last line of the first or upper division of the *Summary Table*, does not show by any means such a variation in the rate of increase among the six lots, when it is thus calculated in relation to their respective weights instead of per head. Still, even in this respect, the Cotswolds stand the first; next come the cross-breds; then the Hampshires and Leicesters; and lastly the Sussex Downs. The rate of increase thus calculated in relation to the average weight of the animal is for the Cotswolds one-tenth more than for the cross-breds, and from one-seventh to one-sixth more than for the Hampshires, Leicesters, and Sussex Downs. It is here worthy of observation, that, excluding the Leicesters, the order in which the different lots gave increase in relation to their weight is obviously pretty nearly the inverse of that of the *quality of the mutton*. That is to say, those which have given the greatest increase in proportion to their weight yield the coarsest mutton, and those which gave the least increase in relation to their weight the finest mutton. Consistently with this view, the Leicesters, however, fall somewhat short in the rate of their increase considering

TABLE XIX.

General Summary of Experiments with Hampshire and Sussex Downs, Cotswolds, Leicesters, Cross-bred Wethers, and Cross-bred Ewes.

PARTICULARS.	40 Hants. Nov. 1850, to May, 1851, 26 Weeks.	40 Sussex. Nov. 1850, to May, 1851, 26 Weeks.	46 Cotswolds. Dec. 1851, to April, 1852. 20 Weeks.	40 Leicesters. Dec. 1852, to April, 1853, 20 Weeks.	40 Cross-bred Wethers. Dec. 1852, to April, 1853, 20 Weeks.	40 Cross-bred Ewes. Dec. 1852, to April, 1853, 20 Weeks.
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Average weight per head when put up	113 7	88 0	119 13	101 5	95 1	91 4
,, ,, ,, when fat (including Wool) . . .	183 1	140 12	183 7	145 14	139 9	133 12
,, Total increase per head .	69 10	52 12	63 10	44 9	44 8	42 8
,, Increase per head Weekly .	2 10¾	2 0½	3 2¾	2 3½	2 3½	2 2
,, Weekly increase per 100 lbs. live weight	1 12¾	1 12¼	2 1	1 12¾	1 14¼	1 14
Average Food consumed per head Weekly . . — Oil-Cake .	7 12¾	6 0½	8 1	5 14	5 14	5 9½
— Clover-Hay	7 0	5 12½	6 14¼	5 9½	5 9½	5 5
— Swedes .	106 3¼	77 12½	113 4	83 13	82 14	78 0
Average Food consumed Weekly per 100 lbs. live weight of animal . . — Oil-Cake .	5 4¼	5 4¼	5 3¾	4 12	5 0	4 15½
— Clover-Hay	4 11½	5 0¾	4 7½	4 8¼	4 12¼	4 11½
— Swedes .	71 10¼	68 0¼	73 6½	67 13	70 10	69 5½
Food consumed to produce 100 lbs. increase of live weight of animal . — Oil-Cake .	291 9½	297 6¼	253 10¼	263 13¾	264 4½	263 8¼
— Clover-Hay	261 6¾	285 7	216 11¾	251 4¾	251 10¾	250 5½
— Swedes .	3,966 12	3,835 12	3,557 8	3,761 0	3,725 4	3,671 0
Average Wool per head	6 4	5 10	9 4¾	8 2¼	6 7	7 3½
Average Wool per 100 lbs. live weight of animal when shorn . . .	3·77	4·57	5·44	5·58	4·60	5·40
Average Dead or Carcass Weights (in stones of 8 lbs.)	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.	st. lbs.
Weights taken at Home. — Of the 4 of largest and 4 of smallest Increase . .	12 6½	9 4	12 6¼	9 4½	9 1½	8 5½
— Of the 8 of medium Increase	12 4¾	9 5¾	12 3½	9 4	9 2¼	8 6¼
— Of the 16 killed*	12 5½	9 5½	12 5	9 4¼	9 2	8 6
Weights allowed at Newgate Market. — Of the 4 of largest and 4 of smallest Increase . . .	12 4	9 2	— —	9 2¼	8 7	8 3½
— Of the 8 of medium Increase	12 2	9 4½	— —	9 2½	9 0¼	8 4
— Of the 16 killed	12 3	9 3	12 2	9 2¼	8 7¾	8 3¾
Proportion of Carcass in 100 lbs. of the *gross*, or unfasted live weight — Of 4 of largest Increase	56·9	57·2	59·1	56·2	56·4	55·0
— Of 4 of smallest Increase	56·4	56·1	57·4	51·9	53·2	55·1
— Of 8 of medium Increase	56·8	57·4	57·8	55·4	55·7	55·3
— Of Total 16 killed . .	56·7	57·0	58·0	54·7	55·3	55·2

* In the case of the Cotswolds, all the averages in this Table are calculated from the results of the 5 of largest, the 5 of smallest, and the 10 of medium increase—in all 20 killed, instead of only 16 killed, as in the case of all the other breeds.

TABLE XIX.—*continued.*

PARTICULARS.		40 Hants. Nov. 1850, to May, 1851, 26 Weeks.	40 Sussex. Nov. 1850, to May, 1851, 26 Weeks.	46 Cotswolds. Dec. 1851, to April, 1852, 20 Weeks.	40 Leicesters. Dec. 1852, to April, 1853, 20 Weeks.	40 Cross-bred Wethers. Dec. 1852, to April, 1853, 20 Weeks.	40 Cross-bred Ewes. Dec. 1852, to April, 1853, 20 Weeks.
Proportion of Carcass in 100 lbs. of the *fasted* live weight	Of 4 of largest Increase	61·2	61·8	62·9	61·6	61·4	61·3
	Of 4 of smallest Increase	60·0	59·3	60·4	57·0	58·7	61·0
	Of 8 of medium Increase	60·6	60·6	61·2	60·8	60·8	60·7
	Of Total 16 killed . .	60·6	60·6	61·4	60·1	60·5	60·9
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Average weight of loose fat *per head*, weighed warm . .	Of 4 of largest Increase .	12 15½	10 4½	8 11¾	8 3¼	7 2	7 7
	Of 4 of smallest Increase	11 5	8 6¾	8 2¼	3 15¼	6 3	6 7
	Of 8 of medium Increase	12 7	10 2½	9 8½	6 8	7 3½	7 2¾
	Of Total 16 killed . .	12 4¾	9 12	8 15½	6 4½	6 15	7 0¾
Proportion of loose fat *in 100 lbs. of the fasted weight* . .	Of 4 of largest Increase .	6·54	7·08	4·57	5·00	5·09	5·74
	Of 4 of smallest Increase	7·34	7·17	5·08	3·59	5·20	5·74
	Of 8 of medium Increase	7·24	7·45	5·53	4·90	5·55	5·84
	Of Total 16 killed . .	7·09	7·29	5·18	4·60	5·35	5·79
Average weight of lung and windpipe *per head*, weighed warm . .	Of 4 of largest Increase .	1 10¾	1 4½	1 14¾	1 6¼	1 8½	1 3¼
	Of 4 of smallest Increase	1 9¾	1 3¾	1 9	1 8¾	1 6½	1 4¾
	Of 8 of medium Increase	1 9½	1 6½	2 0½	1 6	1 5¾	1 3½
	Of Total 16 killed . .	1 9¾	1 5¼	1 14¼	1 6¾	1 6½	1 8¾
Proportion of lungs (including the windpipe) *in 100 lbs. of the fasted weight*	Of 4 of largest Increase .	0·84	0·89	1·01	0·85	1·09	0·94
	Of 4 of smallest Increase	1·03	1·05	0·99	1·43	1·18	1·15
	Of 8 of medium increase	0·93	1·03	1·19	1·05	1·05	0·99
	Of Total 16 killed . .	0·93	1·00	1·06	1·10	1·09	1·02

	1851.		1852.	1853.		
	s. *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*
Average price of the Carcasses, per stone of 8 lbs.	3 0	3 2¼	2 10	4 1½	4 2	4 2
Average gross money return per head of those sold dead (without Wool)	40 8½	32 6½	37 1½	40 9¼	39 11½	38 1
Average gross money return per head of those sold alive (without Wool).	40 4	34 4	35 4	38 4	40 4	37 11½
Average money return of the Wool per head	7 0½	6 6¾	9 8	10 2	9 3½	10 3
Price of the Wool per lb. . . .	1 1½	1 2	1 0½	1 3	1 5	1 5

sidering the somewhat inferior quality of their mutton compared with that of the cross-bred and Hampshire sheep.

In the second main division of the *Summary Table* we have the various particulars of the consumption of food by the different lots of sheep. Leaving the point of the amounts of food consumed *per head*, the variations in which, so far as the dry foods are concerned, depend on the varying original weights of the different lots; and looking only to the amounts consumed *per* 100 *lbs. live weight of animal*, or *to produce* 100 *lbs. of increase*, we see that, although the oilcake and clover-chaff were in each case given in proportion to the original weights of the sheep, yet the result was that, taking the average throughout the entire period of the experiment, the Leicesters had less of these dry foods in relation of their average weight than any of the other lots, and more particularly than the Hampshires, Sussex Downs, and Cotswolds. Notwithstanding this, however, the Leicesters also ate less in relation to their average weight of the *turnips*, which they were allowed *ad libitum*, than any of the other breeds. This less consumption of total food in relation to their weight by the Leicesters might be in their favour, if the result were that they consumed also less for the production of a given amount of increase. But the fact is seen to be, that, in relation to the increase they yielded, the Leicesters consumed quite as much food as the cross-breds, and notably more than the Cotswolds. Leicesters, cross-breds, and Cotswolds, however, all give a larger amount of gross increase for a given amount of food consumed than either the Hampshires or the Sussex sheep. Such are the results of the experiments as they stand on the point of the amount of food required to yield a given amount of increase. But we must not forget that the trials were not all made side by side and in the same season; those with the Hampshire and Sussex Downs being made together in 1850-1, those of the Cotswolds alone in 1851-2, and those with the Leicesters and cross-breds in 1852-3. And although the quality of the respective foods was in all cases as nearly alike as circumstances would allow, yet the actual stocks used were different for the three seasons. There is, nevertheless, much of consistency in the general character and direction of the actual numerical results; which are, indeed, much what we should expect, considering the generally admitted distinctions between the different breeds, though perhaps not on all points what is currently stated of them.

With respect to the *wool*, it is seen that the long-woolled Cotswolds and Leicesters gave the greatest weight, both *per head* and *per* 100 *lbs. live weight of animal;* next in order come the cross-breds; and lastly, the Hampshire and Sussex Downs. The order of highest amount of wool *per head* is—

Cotswolds,
Leicesters,
Cross-bred ewes,
Cross-bred wethers,
Hampshires,
Sussex Downs.

The order of highest amount of wool *per* 100 *lbs. live weight* is—

Leicesters,
Cotswolds,
Cross-bred ewes,
Cross-bred wethers,
Sussex Downs,
Hampshires.

It is worthy of notice, that of the cross-breds, which were fed in the same season and side by side with the Leicesters, the *ewes* gave considerably more wool both per head and per 100 lbs. live weight than the wethers; the female offspring, therefore, inheriting more prominently the qualities of the male parent so far as the *fleece* is concerned. Comparing together the Hampshires and Sussex Downs, which were fed side by side with each other, the Hampshires gave an average of 1¼ lb. more wool *per head;* but the Sussex, on the other hand, gave nearly one-fourth more than the Hampshires *per* 100 *lbs. live weight of animal.*

Looking to the question of the quantity of mutton or weight of carcass yielded by the different breeds thus fed only to the age of about fifteen or sixteen months, it is seen that the Hampshires and Cotswolds averaged nearly 12½ stones (8 lbs. per stone) of marketable meat or dead weight, equal to 24 or 25 lbs. per quarter; these Cotswolds were, however, six weeks' less time on fattening food than the Hampshires, and were nevertheless somewhat too fat. The Sussex Downs and Leicesters gave only about three-fourths as much dead weight per head as the Hampshires and Cotswolds; that is, little more than 9¼ stones each, equal to about 19 lbs. per quarter; the long-woolled Leicester again giving an equal weight of mutton with the short-woolled Sussex after six weeks' shorter time on fattening food, though probably, it is true, not in point of fact six weeks younger, owing to their earlier date of lambing. Of the cross-breds, the wethers gave about 9, and the ewes about 8½ stones of meat per head—equal respectively to about 18 and 17 lbs. per quarter.

The Hampshires, therefore, after an equal length of time on fattening food, were brought to about one-third more carcass-weight per head than the Sussex sheep. The Cotswolds, with six weeks less on fattening food than either the Hampshire or

Sussex sheep, gave an equal carcass-weight with the former and one-third more than the latter. And again, the Cotswolds, with an equal length of time on fattening food, gave about one-third more carcass-weight than the Leicesters, and nearly one-half more than the cross-breds.

The next point to notice in the *Summary Table* is the proportion of the dead or carcass-weight to live-weight—an item which, other things being equal, may be taken as indicating the comparative tendency to *carcass* growth generally and early maturity. The figures in the Table do not show any very great differences among the six lots, but, such as they are, the result of the comparison differs somewhat accordingly as we calculate the carcass-weight in relation to the *fasted* or to the *un*fasted live-weight. And since, when calculated on the *fasted* weight, the result is less influenced by the incidental contents of the stomach, we assume that method to give the safest ground for comparison.

It will be remembered that the Hampshire and Sussex sheep were nearly one-third longer time on fattening food than any of the other lots, and this should be all in their favour as far as proportion of dead weight to live is concerned. It is seen, however, that the *Cotswolds*, although fed six weeks' shorter time, gave a higher percentage of carcass than either the Hampshire or Sussex Downs. Indeed the Cotswolds had more of the tendency to increase and fatten in *carcass* for the food they consumed than any of the other sheep. But the quality of their mutton is certainly inferior, and will command a somewhat lower price. The Leicesters gave a less proportion of deadweight than any of the other sheep—even than their cross with the Down—fed side by side, and for an equal length of time. This is not what would be expected, for the current character of the Leicester, like that of the Cotswold, is certainly to yield carcass rather than inside growth. The crosses again, though fed six weeks' shorter time than the pure Hampshire and Sussex Down, still give an equal proportion of dead weight to live.

The tendency to give large proportion or percentage of carcass weight, is certainly generally coincident with that of laying on fat on the carcass rather than inside. This character, which is that of *early maturity*, and which is favoured by the modern system of rapid fattening, is certainly somewhat unfavourable to high *quality* of mutton. This *carcass fattening* bespeaks a languid, though full circulation, and less of muscular or motive activity, and with this less of the hardiness dependent on respiratory vigour. The cross-breds, however, in these experiments, gave both an equal tendency to carcass growth with the pure Lei-

cesters; and they also fetched a somewhat higher price per stone of mutton, though the difference in this respect was probably less than it would have been, had not our Leicester mutton, from their want of growing character, been more delicate than usual, and our cross-bred on the other hand rather under the mark for want of a little more time. Our next observations will further illustrate the above points of comparison.

The Hampshire and Sussex Downs gave the largest proportion of loose, or caul and gut fat. This is consistent with the known comparative less tendency of the hardier Downs to give very fat carcasses, and also with the known superior quality of their mutton. It must not be forgotten, however, that in these experiments the Downs were the longest on fattening food which would favour their production of fat generally; but this was obviously deposited over the internal viscera rather than on the carcass, or muscular and motive part of the body; for whilst they gave the highest proportion of inside fat, they did not give a high proportion of dead or carcass weight. The cross-breds again gave a larger proportion of inside fat than the Cotswold, or than the pure Leicesters, and the ewes rather more than the wethers. Thus, in this internal character, the crosses inherit more of the qualities of the female parent, and the female offspring rather more so than the male. These qualities of the crosses are quite consistent with their admitted hardier character as compared with the pure Leicesters, and also with the better quality of their mutton.

The degree of development, or activity of *lung*, is certainly, other things being equal, coincident with the habits of activity or rest, and with the character for hardiness of the animal. Those animals adapted or accustomed to more of exposure and exercise should doubtless have a greater development of lung and of respiratory and circulatory activity; and with this would go less tendency to massive accumulation of fat on the carcass, or motive part of the body. Activity or large development of lung, a less fat carcass, a higher quality of mutton, a greater hardiness, and more of inside fat, should thus go together.

Our figures relating to the proportional weight of lung in the different cases are not so consistent with these general principles as we should have expected, when we compare together all the six lots of sheep. Those relating to the other points involved we have seen are so, and those relating to the weights of lung are indeed consistent when comparing together only certain lots—as for instance the Hampshire and Sussex Downs—and some of the cases of inconsistency are perhaps not incapable of some explanation. Thus the higher average proportional weight of

lung of the Cotswolds, Leicesters, and cross-breds, than the Downs, would probably have been lessened had the former been as long on fattening food as the latter. Again, the higher proportion of lung among the Leicesters than the cross-breds is not what we should expect, but the higher *average* among the former is obviously due to the very high amount of those of the Leicester sheep of *smallest increase.* This excessive proportion of lung is consistent enough with very little tendency to increase; and we find indeed the largest proportion of lung among the animals of *smallest increase*, in the case of every lot except the Cotswolds. It may be, however, that activity of respiratory function is not, under all circumstances, indicated by comparative *weight* of lung alone. A comparison of the proportional weights of the heart, and the other internal organs or viscera of animals of different breeds, or differently fed, would be unsuited to the objects of this paper; but this is a subject which it is our intention to treat of on some other occasion, together with that of the comparative composition in a more chemical point of view of our domestic animals in different conditions of fatness or maturity.

Comparing then together all the six lots, the results as a whole pretty generally confirm the usually current views as to their characteristic tendencies and qualities. And, in a word, it may be said that the greater the tendency to rapid growth, to early maturity, and to give a large proportion of gross increase to food consumed, the fatter will be the carcass, the coarser the mutton and wool, the less the proportion of butcher's valuable offal, and the less the hardiness of the animal under exposure and exercise. Thus the Cotswolds and the new Leicesters (though the latter have certainly not fully borne out their current character in these experiments), if they do possess the quality of giving a comparatively large return of gross increase for food consumed, they at the same time give fatter carcasses, are less hardy, give less valuable offal, and yield a lower price for a given weight, both of mutton and wool, than either the Downs or their crosses.

This brings us to the consideration of the comparative money value of the different lots. In the concluding lines of the *Summary Table* are given the prices per stone (8 lbs.) of mutton, the money return per head sold dead and sold alive (excluding wool), and the return per head, and the prices per lb. of the wool, as realized in the actual sales of the experimental sheep. Since, however, some of these sales were not only made in different markets from the rest, but even in different years, no general comparison of them can be made; hence the "*Balance Accounts*" which have been given from time to time, as affording the best

means the circumstances admitted, of an approximate comparison in a money point of view, between the lots fed side by side, cannot be employed in any way in comparing together the result of the whole six lots.

If, however, we could arrive at any satisfactory manner of estimating the average money value of the lambs of the respective breeds, we could then institute a pretty safe comparison of the money return of the different lots; for, on the one hand, the dry foods could be taken at one uniform rate for all, and, on the other, the Tables which are published of the *Average Prices* of the different descriptions of mutton and wool, would enable us to put all on the same footing, so far as the *produce of sale* is concerned.

No satisfactory comparative estimate of the average cost of the respective lambs, at a given age or weight, can be made. To say nothing of the variation in different seasons or localities, according to the supply of food and other matters, the methods of business adopted in the rearing or procuring of stores of a pure breed, and of a first cross, are necessarily so different in themselves, independently of the influence of locality on the two modes, that any attempt to form an estimate of the average comparative value of the different kinds of lambs could only yield a fallacious basis for any further calculations.

Perhaps the safest way of applying the results of the experiments, to institute a comparison of the relative economy of the different lots as rapid fatteners, is, then, to set aside altogether the question of the relative prices of the lambs, and to take into account only the relative amounts of food required to yield a given weight of the fattened animal in the different cases, and the average comparative value of the mutton and wool produced. That is to say, if we take the amount of food consumed by each lot to produce 100 lbs. of live weight on the one hand, and the *average* money value of 100 lbs. live weight of each of the different descriptions of sheep on the other, we have a pretty fair means of forming an approximate comparison of the economy at least of feeding, if not of the rearing of the respective lots.

Setting aside then the actual prices obtained for the different descriptions of mutton and wool, we have in the following Table (XX.), which is compiled from *Bell's Weekly Messenger* of January 1851, the average price at Smithfield Market, and during a period of ten years, namely, from 1840 to 1849 inclusive, of different descriptions of mutton per stone of 8 lbs. to sink the offal.

TABLE XX.

TABLE XX.

Years.	Prime South Downs.		Prime Coarse-woolled Sheep.	
	s.	*d.*	*s.*	*d.*
1840	4	11	4	6
1841	5	0	4	8
1842	4	8	4	4
1843	4	4	4	0
1844	4	8	4	3
1845	5	1	4	10
1846	4	9	4	4
1847	5	7	5	1
1848	5	3	4	10
1849	4	5	3	10
Average of 10 years	4	10½	4	5½

Now, if we take our Sussex sheep as "prime South Downs," our Leicesters and Cotswolds as "prime coarse-woolled sheep," and our Hampshires and cross-breds as intermediate between the two, we have the average relative price per stone of 8 lbs. of our six lots of mutton, as given in the following Table (XXI.). It may, perhaps, be objected by some, that Cotswold mutton, from its large size, should not be taken at quite so high a rate as the Leicester; but we are disposed to think that if brought as early to the butcher as the liberal system of feeding we are supposing implies, the former would, in ordinary markets, fetch an equal price per stone with the latter. However, as the data and plan upon which our estimates are framed will be fully before the reader, he can easily amend our figures and carry out the calculations on this or any other point as he may think fit.

TABLE XXI.

Description of Sheep.	Average Price per Stone of 8 lbs. to sink the offal.	
	s.	*d.*
Sussex Downs	4	10½
Hampshire Downs	4	8
Cross-bred wethers	4	8
Cross-bred ewes	4	8
Leicesters	4	5½
Cotswolds	4	5½

In the following Table (XXII.) we have computed from the weekly lists given in 'The Economist' the average prices per lb. of different descriptions of wool (in fleeces), taken from the

entries of nearly every week, over a period of nearly five years, namely, 1850 to 1854 inclusive:—

TABLE XXII.

Years.	South Down Hogs.	South Down Ewes and Wethers.	Half-bred Hogs.	Leicester Ewes and Wethers.
	s. d.	*s. d.*	*s. d.*	*s. d.*
1850	1 1¼	0 10¾	1 1½	0 9¾
1851	1 2	0 11½	1 2¼	0 11
1852	1 3½	1 0¾	1 3¼	0 11¾
1853	1 5¼	1 3¾	1 4½	1 3¼
1854	1 2¼	1 1¾	1 1¾	1 1
Average of 5 years ..	1 2¾	1 1	1 2½	1 0¼

We have here the average price per lb. over a period of nearly five years of the wool, both of the hoggets and of the ewes and wethers, of the South Downs, that of the former being nearly 2*d.* more than that of the latter. Of the Leicesters, we have the price of the wool of the ewes and wethers only. There would certainly, however, be on the average a less difference than 2*d.* per lb. between the price of the hogget and of the ewe and wether wool, in the case of the long-woolled sheep. If, therefore, we raise the average price of 1*s.* 0¼*d.*, as given in the table for Leicester ewe and wether wool, to 1*s.* 1*d.* for that of Leicester hoggets, this will probably give a fair average price, compared with that of the other descriptions. We have been unable to find any collateral published price for Cotswold hogget wool; but we suppose that we may assume it the same as for the Leicester for our present purpose.

Upon these data, then, we take the average relative prices per lb. of the wool of our six descriptions of experimental sheep, as given in the following Table (XXIII.); but subject, of course, as before, to the emendation of the reader, if his judgment do not agree with our own.

TABLE XXIII.

Description of Sheep.	Average Price of Wool per lb.
	s. d.
Sussex Downs	1 3
Hampshire Downs	1 3
Cross-bred wethers	1 2½
Cross-bred ewes	1 2½
Leicesters	1 1
Cotswolds	1 1

In the next table, the foregoing data of the *average prices* of our saleable produce—mutton and wool—are applied to form some estimate of the probable comparative economy of the different lots of sheep as early fatteners, and when fed under cover. In this Table (XXIV.) we have—for each description of sheep,—

The foods consumed to produce 100 lbs. increase in live-weight.

The *extra food beyond Cotswolds* (which consumed the least), consumed to produce 100 lbs. live-weight.

The quantities of marketable produce—mutton and wool—contained in 100 lbs. of the *unfasted live-weight with shorn wool added.*

The money-return, at *average rates*, of the mutton and wool in 100 lbs. live-weight.

Difference of money-return *over or under that of Cotswolds* for 100 lbs. live-weight.

Cost of *extra food consumed beyond Cotswolds* to produce 100 lbs. live-weight: the oilcake reckoned at 1*d.* per lb. = 9*l.* per ton; the clover-chaff as ½*d.* per lb. = to 4*l.* 10*s.* per ton; and the Swedes at 4*d.* per cwt., consumed on the farm, = 6*s.* 8*d.* per ton.

And, lastly, the difference or excess of extra cost of food over money-return for 100 lbs. live-weight, compared with Cotswolds.

According to the figures in this Table (XXIV.), in no case does the average extra price of the mutton and wool of the more choice descriptions of sheep, compensate for the cost of the extra food which has been consumed to produce them. It may be objected to our exact figures, that all the experiments were not made side by side, and during the same period, and that therefore both difference of season and some variation in the quality of the roots may, perhaps, in a degree affect the results; nor, perhaps, is the method of estimate adopted free from all objection. It is, however, the safest we can adopt; and, we believe, that the results give a fair indication, at least of the *direction* of the comparative economy of the different lots, considered as early fatteners, and fed under cover.

It is quite consistent with the physiological distinctions which must characterise animals adapted to more of exposure and exercise, that they should—as in the experiments they were found to do—consume more food to produce a given weight of increase than the opposite description of animal. The experimental results should therefore, as we have said, be taken as certainly in the right *direction*, whether or not they exactly represent *quantitatively* the relative fattening qualities under the system adopted, of the different lots. And, again, this extra food required for a given amount of increase, and the greater

TABLE XXIV.

Description of Sheep.	Average Food consumed to produce 100 lbs. Increase in Live Weight.			Extra Food *beyond Cotswolds* consumed to produce 100 lbs. Live Weight.			Marketable Produce in 100 lbs. unfasted Weight, including Wool.		Money Return at *Average Rates* of 100 lbs. Live Weight.			Difference of Money Return *over* or *under Cotswolds* for 100 lbs. Live Weight.	Cost of *Extra Food consumed beyond Cotswolds* to produce 100 lbs. Live Weight.	Difference or Excess of Extra Cost over Money Return for 100 lbs. Live Weight compared with Cotswolds.
	Oilcake.	Clover.	Swedes.	Oilcake.	Clover.	Swedes.	Mutton (sinking offal).	Wool.	Mutton (sinking offal).	Wool.	Total.			
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. ozs.	lbs. ozs.	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*
Sussex	297¼	285½	3,835¾	43¾	68¾	278¼	53 3	4 0	32 5	5 0	37 5	+1 11¾	7 4	5 4¼
Hampshires	291½	261¼	3,966¾	38	44½	409¼	53 6	3 7	31 1½	4 3½	35 5	—0 0¼	6 2¾	6 3
Cross-bred wethers	264¼	251¾	3,725¼	10¾	35	167¾	51 2	4 10	29 10	5 7	35 5	—0 0¼	2 10¼	2 10½
Cross-bred ewes..	263½	250¼	3,671	10	33½	113½	50 10	5 6	29 6½	6 6	36 0½	+0 7¼	2 6¾	1 11½
Leicesters	263¾	251¼	3,761	10¼	34½	203½	50 11	5 9	28 3	6 0¼	34 3¼	—1 2	2 10¾	4 0¾
Cotswolds	253½	216¾	3,557½	..	..	..	53 6	5 4	29 9	5 8¼	35 5¼			

hardiness or power of resistance to cold from without, bespeak more of motive or muscular activity, and a larger respiratory expenditure, and consequently greater resource of internal temperature. It is in this way that we pay for the increased quality of the meat, induced by a greater circulatory activity of the fluids of the body, and a slower and less massive deposition of fat.

We must not, however, place the whole of the extra food consumed to the cost of the mutton and wool; for most of its nitrogen will be recovered in the manure, the value of which will therefore be increased in a certain degree in proportion to the extra food consumed. Then, again, a due consideration of the invaluable working qualities, and the more choice mutton of the hardier kinds of sheep, which always give them the preference over the earlier fattening long-woolled breeds in certain localities, with certain descriptions of farming, and in certain markets, will at once show that any conclusions from the comparison of cost, brought out in these experiments with very liberal feeding and protection from the weather, must be applied with much caution, in seeking to form an estimate of the comparative qualities of the different breeds under widely different circumstances.

In conclusion: it must be admitted, that, as is already well known, the Downs and their crosses are better adapted to exposure and activity than the long-woolled sheep. It would seem, however, that when liberally fed, and protected from inclement weather, the long-wools, especially the Cotswolds, will yield a larger amount of gross increase for a given amount of food consumed than the Downs or crosses. The *average prices* of Down, and also of cross-bred mutton and wool, are, however, higher than for those of the long-wools; but not sufficiently so to compensate for the cost of the extra food consumed. It would appear, therefore, that when equally fitted to climate, locality, and system of farming adopted, both as to their rearing and fattening qualities, and when on the other hand what may be termed a fancy or over average price for Down mutton is not attainable, those animals yielding most mutton and wool for a given quantity of food, will have an advantage in supplying the demand of the *masses* of the population. The cross-breds, however, seem to have in several respects very valuable intermediate qualities between the hardy Downs and the more rapidly fattening long-wools; though it must not be forgotten that these advantages of the cross-breds cannot be maintained unless the pure breeds from which they are derived are duly cultivated and kept up. And it

is fortunate that so undoubted is the superiority of the pure breeds, under certain circumstances and in certain localities, that we need have no fear of the deterioration of our crosses on that score.

In other words, it results that although there is an evident relation between the amount of food required to produce a given quantity of mutton, and the quality or value of the mutton produced, yet the variations in the rate of increase to food consumed on the one hand, and in money-value on the other, are not of themselves sufficient to afford any decisive conclusion as to the comparative economy of the different breeds founded *merely on the productiveness of the food* under certain circumstances of fattening. Perhaps the result of the comparison of the several breeds in this one respect is as satisfactorily brought out in these experiments as we can hope it will be *experimentally* at all. And it would seem that the farmer must, after all, be guided in his choice mainly by the many practical and business considerations which it is not within the province of such investigations as those we have recorded directly to illustrate.

So much, then, for the comparative fattening qualities of the several breeds, when protected from the weather and fed rapidly for the market upon a liberal supply of good food. We have seen that although the extraordinary rates of increase frequently spoken of have not been met with (nor were they expected) in these somewhat extensive and carefully conducted experiments, yet it is strikingly brought out that under the modern system of rapid fattening with a liberal supply of purchased or saleable food, a weight of mutton can be produced in fifteen to eighteen months, which not long since generally required at least twice that period. And if the quality of the rapidly-fed mutton is not quite equal in the judgment of the rich and connoisseur, there can still be no doubt which course must be adopted in the long run in the production of food for a large and increasing population and demand.

Although, however, we have already carried our Report of the progress of our comparative experiments with the different breeds only up to the point at which good marketable mutton may be produced, yet, as frequently alluded to in our papers, a few of each of these lots of sheep were fed for some six months more; and the results of these extra or somewhat over-fattened sheep must form the subject of a supplementary and separate Report.

The following is a short enumeration of useful and practical facts relating to sheep-feeding, which our experiments have brought out:—

sumption of Food:—

Sheep of different breeds consume quantities of food in proportion to their respective weights when at an equal age, stage of feeding, &c.; that is to say, three sheep weighing 100 lbs. each will consume the same quantity of food as two sheep of 150 lbs. each.

Sheep on good fattening food—such as cake or corn, with chaff and roots—will consume weekly about $4\frac{3}{4}$ lbs. of cake, $4\frac{3}{4}$ lbs. hay, and about 70 lbs. of roots, for every 100 lbs. of their live-weight.

When fed as above, they will consume every week about one-seventh of their own weight of the *dry* substance of food; that is, after deducting the moisture it contains.

Rate of Increase:—

Sheep well fed and under cover will increase about two per cent. per week upon their weight; that is to say, 100 lbs. live-weight will increase from $1\frac{3}{4}$ lb. to 2 lbs. per week.

To increase 100 lbs. in live weight, sheep will consume about $2\frac{1}{4}$ cwts. of cake or corn, $2\frac{1}{4}$ cwts. of hay-chaff, and $1\frac{1}{2}$ to $1\frac{3}{4}$ tons of roots.

The increase of a fattening sheep is at the rate of about 1 lb. live-weight to 8 lbs. or 9 lbs. of the *dry substance of the food* consumed.

Live and Dead Weights, &c.:—

Hoggets or tegs (under twelve months old), and in a lean or store condition, will contain about one half of their weight carcass, and about one half offal.

Shorn sheep, sufficiently fat for the market, will contain about 56 lbs. of carcass in every 100 lbs. of the unfasted live-weight.

Sheep in an ordinary state of fatness yield from 7 lbs. to 14 lbs. of offal or loose fat per head, according to breed and size; the long-wools giving the least, and the Downs the most.

Value of Increase, &c.:—

The value of the increase of fattening sheep is less than the cost of the food consumed to produce it; the difference is to be charged to the manure.

The value of the total offal is from 4*s.* to 6*s.* per head, independently of the wool.

IV.—*Report of Experiments made with various Manures for subsoil, by* MR. KEMP BOURNE, *of Fisherwick, near Lichfield, Chemistry*

No.	Manure used.	Price per Ton.			Quantity per Acre.			Cost per Acre.		
		£.	s.	d.	cwt.	qrs.	lbs.	£.	s.	d.
1	Flesh Manure	6	15	0	8	1	0	2	15	8
2	Proctor and Ryland's Turnip Manure	8	0	0	7	2	0	3	0	0
3	Shoddy, 30*s.* Carriage, 20*s.*	2	10	0	11	0	0	1	7	6
	Guano, Peruvian	9	15	0	2	2	14	1	5	7½
	Salt	0	13	6	2	2	14	0	1	9
								2	14	10½
4	Guano, Peruvian	9	15	0	5	1	0	2	11	2
	Salt	0	13	6	5	1	0	0	3	6
								2	14	8
5	Proctor and Ryland's Turnip Manure	8	0	0	6	3	14	2	15	0
6	Shoddy and Carriage	2	10	0	16	0	0	2	0	0
	Dissolved Bone, containing 18 per cent. of Phosphoric Acid	7	0	0	2	0	0	0	15	0
								2	15	0
7	Flesh Manure	6	15	0	4	0	14	1	7	10
	Guano, Peruvian	9	15	0	2	2	14	1	5	7½
	Salt	0	13	6	2	2	14	0	1	9
								2	15	2½
8	Shoddy and Carriage	2	10	0	11	0	0	1	7	6
	Guano, Peruvian	9	15	0	2	2	14	1	5	7½
	Salt	0	13	6	2	2	14	0	1	9
								2	14	10½
9	Flesh Manure	6	15	0	4	0	14	1	7	10
	Guano, Peruvian	9	15	0	2	2	14	1	5	7½
	Salt	0	13	6	2	2	14	0	1	9
								2	15	2½
10	Guano, Peruvian	9	15	0	5	1	0	2	11	2
	Salt	0	13	6	5	1	0	0	3	6
								2	14	8

The sort of Turnips—Green Rounds, drilled in rows, near two feet distant, and well hoed. The land clean, and in a high state of cultivation.

NOTE.—The result of these experiments goes to prove that on turnip land of this character neither *insoluble Phosphates* nor *unformed Ammoniacal Salts* will answer so well for the Turnip plant as *soluble Phosphates* and *ready-formed Salts of Ammonia;* though there is a discrepancy between Nos. 3, 4, 8, and 10, which cannot be explained, except that there was more chicken weed on Nos. 3 and 4.

It was intended that the materials of No. 6 should have been mixed for some weeks before being used, in order to have given time for the formation of Am-

the Turnip Crop, on a light grey sandy soil with a yellow sandy and published at the request of the Tamworth Agricultural Association.

Ammonia, *free*, per Acre.	Ammonia, *fixed*, per Acre.	Phosphoric Acid, *soluble*, per Acre.	Phosphoric Acid, *insoluble*, per acre.	Weight of Turnips per Acre, 23rd Nov. 1853.			When sown.	Observations.
lbs.	lbs.	lbs.	lbs.	tons	cwt.	qrs.		
—	65½	—	126	18	17	3	No. 1 to 7, sown July 6th, after Tares eaten off by Sheep.	Aug. 6, growing slowly. Much injured by chickweed.
21½	8½	51½	80½	24	10	1		Aug. 6, growing very fast. Sept. 16, the best plot, but injured by chickweed.
28	96	5¾	37½	23	6	3		Aug. 6, growing fast. Sept. 16, good, and growing fast. Second-best plot.
56	43	11½	74½	22	12	1		Aug. 6, growing very slowly. Sept. 16, good, and growing very fast. Fourth-best plot.
19	7½	45½	72	24	9	2		Aug. 6, growing fast. Sept. 16, equal to plot No. 7. Third-best plot.
—	111	40	22	21	15	3		Aug. 6, growing fast. Sept. 16, Middling. Worst, except No. 1.
28	54½	5¾	100½	23	7	2		Aug. 6, growing fast. Sept. 16, equal to plot 5. Third-best.
28	96	5¾	37½	24	18	1	No. 8 to 10, sown July 1st, 1853, after Rye eaten off.	Aug. 6, growing fast. Sept. 16, growing slowly; the least weight of turnips, but better quality than plots 9 and 10.
28	54½	5¾	100½	25	16	1		Aug. 6, growing very fast. Sept. 16, second-best; but a great many rotten turnips.
56	43	11½	74½	26	5	1		Aug. 6, growing slowly. Sept. 16, the best plot; but many rotten.

monia, as directed at p. 220 in Haywood's Letters to Farmers; but the time would not allow of this being done.

51 lbs. of soluble Phosphoric Acid can be obtained by mixing 245 lbs. of ordinary bones with 100 lbs. of common Sulphuric Acid; and 21 lbs. of free Ammonia by adding to it 95 lbs. of Sulphate of Ammonia.

The Turnips were inspected, weighed, and reported on, by Mr. Edward Farmer and Mr. Farmer Cheatle.

The quantities of Ammonia and Phosphates, and the general result of the experiments, as stated above, were given by Mr. James Haywood, of Sheffield, the late lamented Lecturer and Analyst to the Society.

THOMAS ARGYLE, Secretary.

V.—*On the Comparative Value of different Artificial Manures for raising a crop of Swedes, with Remarks on the Composition of the Manures employed in Experimental Trials made at the Royal Agricultural College, Cirencester.* By Dr. Augustus Voelcker, Professor of Chemistry in the Royal Agricultural College, Cirencester.

It is strange, that whilst an extended experience has proved in the most positive manner the specific action of phosphatic manures, and the decided advantages which result from their application to root crops, the employment of manures either greatly deficient in phosphoric acid, or wanting altogether this important fertilizing agent, should still be recommended by some practical men for raising a crop of swedes, turnips, or any other root crop. No less strange appears the preference which some farmers give even to half-inch bones over superphosphate of lime, although the superior value of the latter fertiliser has been ascertained in numerous practical experiments, and consequently has been recommended by high agricultural authorities, as by far the most economical form in which bones ought to be applied to the land. Still more surprising appears the ready sale which many artificial manures find, although their composition plainly indicates the utter worthlessness of the manufactured article, or the great discrepancy between the price at which it is offered for sale, and its per centage of really valuable fertilising constituents. But strangest of all, it strikes us, is the fact that the sale of downright trashy manures, or to say the least of them manures of a very inferior description, is often perpetuated for a long time by high flourished testimonials, given by men of character, and possessed of a degree of practical skill which entitles them to a considerate hearing. It is further worthy of observation, that valuable artificial manures are often employed even by good farmers in the cultivation of crops on which, as experience has proved, they are used with far less advantage than on others. Thus for instance, in many parts of England, but more especially in Scotland, Peruvian guano is used extensively as a manure for turnips, in preference to superphosphate of lime, notwithstanding the publication of numerous comparative field experiments, which have established the superior value of superphosphate as a manure for root crops, and which have shown likewise that the greatest fertilising effect of guano is realised by applying it to a white crop or to grass land.

Strange as these facts may appear at first sight, yet a little consideration, I think, will point out the reasons on which the objectionable practices to which reference has just been made are founded. Is there not afforded a clear proof in these and similar

practices, that a knowledge of the principles on which the fertilising effects of manuring matters depend is by no means so generally spread amongst the agricultural community as it is desirable it should be? Do they not show that the specific action even of our standard fertilisers is unknown to many, and that consequently the choice of a manure for a particular crop is more regulated by chance or habit than by a consideration of the peculiar effects on vegetation which characterise many manures? How often do we not see a manure which has been employed upon wheat with considerable benefit, indiscriminately applied on every description of crops? Do we not recognise in some of the facts to which allusion has been made, a reluctance of many to change a manure which hitherto has been used with advantage for another, recommended by the best authorities as a superior fertiliser? and on the other hand a willingness in others to submit to an experimental test that which is not really worth the trouble of trial? I do not doubt most readers will reply to these queries in the affirmative. But, I think, we may recognise still more in the proffered observations. It strikes me, that a trial in the field with different manuring matters is often considered an easy thing, whereas it is in reality a difficult task to perform a good field experiment. The reasons of this are obvious. The neglect of a single point which ought to have been attended to in the execution of an experimental trial in the field, or the commission of a fault, which cannot in this instance be so readily remedied as many other mistakes, or uncontrollable circumstances which interfere, but which pass by unnoticed, at once spoil the final result of the experiment, and consequently the inferences deduced from it are erroneous and apt to lead astray. Indeed a review of most published experimental field trials has convinced me, that comparatively speaking few have been undertaken with that amount of caution, candour, care, practical and scientific skill, premeditation, power of observation and general intelligence, which is requisite for the performance of a field experiment from the result of which trustworthy practical inferences can be deduced; and I have no hesitation in saying that the suppression of the majority of our recorded field trials with different manures would be a benefit to the agricultural community, inasmuch as they are calculated to mislead instead of to direct the practical man in his operations on the farm.

Then again, often no regard is had to the composition and physical properties of the soil on which experiments are tried; no notice is taken of the mechanical state of preparation in which it is found at the time when the experiment is made; casualties, such as the partial destruction of the crop by insects, unpropitious weather, &c., are overlooked; manures differing

widely from each other in composition, and consequently possessing totally different specific actions on vegetable life, are tried against each other; or powerful fertilisers occasionally are employed in quantities, or in a mode in which they injure instead of benefiting the plants; and a variety of other mistakes not seldom are committed, and other circumstances of importance overlooked, which all tend to affect the result of the trial. Thus for instance, experiments with different fertilisers occasionally are tried on land which is in so excellent a condition that the best manure hardly makes any impression on the yield of the crop. It is forgotten that the agricultural capabilities of soils cannot be increased *ad libitum* to any extent, and that consequently the addition of the most valuable fertiliser to land which has almost reached its maximum state of fertility, which it either possesses naturally, or into which it has been brought by long cultivation, will produce no more effect than the most worthless manuring mixture. Land in such a high state of fertility can be compared to the replenished stomach of a well fattened animal; the one is as little benefited by the best manure, as the other is by the choicest food. On the contrary, the most powerful fertilisers applied under such conditions are exactly those which may and do occasionally even produce undesirable effects on vegetation, just as the richest food is more apt to spoil a satiated stomach than a plainer dish.

Hence it is that statements to the effect that such or such a manure has produced as great an effect as the best Peruvian guano, or any other manure of well-known fertilising power, or has even surpassed the best manures in its effects, find their way into the hands of dealers in trashy manures, or to say the best of the manures of a very inferior description. For this reason the printed testimonials which accompany the offer for sale of artificial manures do not always possess that value which many attach to them, not even when they are the genuine emanations of well-known and strictly honest agriculturists; for as I have said already, trustworthy inferences from the results of experimental trials can only be drawn, if a vast variety of circumstances are taken into account, the recognition of which requires much experience, and I am almost inclined to believe, a special training for this branch of experimental inquiry. Comparatively speaking, few men accustomed to practical pursuits during the greater part of their life, and dependent for the support of their families upon their business, are in a position to execute and direct field experiments with sufficient accuracy for the results to confer any permanent benefit on the farming community. It is indeed an unjust accusation which is sometimes made against the practical

farmer, that he has little inclination for undertaking experimental trials in the field.

Another circumstance to which reference has been made as calculated to vitiate the results of field experiments, and to give rise to erroneous views with regard to the value of fertilising materials, is the improper state in which otherwise good manures are occasionally applied to the land. An example or two, which came under my personal observation, will I hope bear me out in making this remark. I have repeatedly heard it asserted by good farmers, who had tried both the ammoniacal liquor of gas-works, and the refuse tar at the same manufactories, that gas-tar produced a much better result on grass and wheat than the ammoniacal liquor, and that consequently the former refuse was worth more in an agricultural point of view. On further inquiry I learned the reason of the small estimation in which this liquid was held by those who preferred to employ the gas-tar as a manure. The ammoniacal liquor, I was told, burns up the grass, whilst gas-tar makes it look more green and succulent. Here we have a striking example in illustration of the entertainment of erroneous views, to which an improper application of manures is apt to lead. Ammoniacal liquor of gas-works is far too powerful a manure to admit of its application in an undiluted form, and when used unmixed with water or any other diluting substance, as was here the case, it invariably burns up vegetation almost completely, unless a continued fall of rain provides for the necessary dilution, which has been neglected by the farmer.

Ammoniacal liquor owes its chief fertilising value to the ammonia, which exists in it almost altogether as a carbonate, and contains nothing detrimental to vegetable life; but like oxygen, which is so essential for animal life, carbonate of ammonia must be considerably diluted in order that it may produce a beneficial effect. In gas-tar, on the other hand, but little carbonate of ammonia is present; and for this reason it may be applied to the land undiluted, without fear of burning up the young plants. But it does not follow from this that gas-tar is a more valuable manure than the ammoniacal liquor, for it is easy to prove that gas-tar is only in so far valuable as a manure, as it is mixed with the watery ammoniacal liquor of gas-works. Both these refuse matters are collected together in one tank, and some of the watery ammoniacal liquor therefore remains always mixed with the tar. In the tar itself there are present no substances which contain either nitrogen, phosphoric acid, or potash, nor indeed any constituent which has the slightest fertilising value; for the organic, resinous, and oily compounds occurring in gas-tar are all compounds of carbon and hydrogen, or carbon, hydrogen, and oxygen, and as such they will furnish, on ultimate

decomposition, carbonic acid and water only. But as all cultivated soils contain vegetable remains, which afford a much more ready and liberal source for carbonic acid, and as, moreover, by far the greater proportion of the carbon in plants is derived from the carbonic acid existing in the atmosphere, it is needless to make special provisions for the supply of carbonic acid. I have admitted for brevity's sake that tarry matters are readily decomposed, which, however, is by no means the case, for every one knows that tar is extensively employed for preserving timber from decay. As far as tar itself is concerned, I am therefore inclined to ascribe to it an injurious effect as a fertiliser, for it must retard the decomposition of organic remains in the soil or in the compost heap to which it is added, and must thus delay the necessary preparation to which most organic refuse matters must be submitted before they can be assimilated by the growing plants. If notwithstanding gas-tar produces a good effect, it is only on account of the ammonia contained in ammoniacal liquor with which it is mechanically mixed. There cannot remain, however, a shadow of a doubt, that the ammoniacal liquor is a far more powerful and at the same time economical manure, which will produce no injurious effects, and just as beneficial effects as gas-tar, when properly diluted with water. And as ammoniacal liquor is cheaper than gas-tar, and as a fertiliser goes at least ten times as far as the tar, the utility of knowing on what principle the fertilising effects of both refuse manures depend will become at once apparent.

Again, shoddy, a wool-refuse of flock-works, is recommended by some as an excellent manure for wheat and corn crops in general, whilst others condemn it as quite useless. How can these differences of opinion be reconciled, when equally good men have ascertained practically the value of shoddy, and know by experience what it is worth as a manure? I have seen shoddy applied to wheat apparently without the slightest effect, and in other cases the effect produced by the same refuse on wheat was wonderful. A reference to the analysis of shoddy, and a consideration of the physical condition of the soils to which and the time at which it is applied, readily explain this contrariety of opinion. Shoddy often contains 20 to 25 per cent. of oil, which, by excluding air and moisture from the interior of the wool-hairs which compose this refuse, prevents its decomposition as effectually as the oil in the sardines à l'huile protects the fishes, or a cover of grease the potted meat. At all events, the oil in shoddy retards its decomposition for a very long time; and as it naturally contains hardly any constituent which is of much value as a fertilizer, no effect is produced if shoddy is applied to the land when the young blade of wheat has already made its appearance,

or even if it is applied two to three months before that period. But if the same refuse is added to the land long before the sowing of the crop which it is intended to benefit, or if by some means or the other it is brought into a state in which it will readily ferment, in which case it may be applied at once to the young wheat, a very marked effect will be observed to follow the application of shoddy to corn crops. For under these circumstances shoddy, which contains from 3 to 5 per cent. of nitrogen, gradually will give rise to the formation of ammonia, which it is well known benefits cereals in an especial manner. In light and porous soils this necessary preparation proceeds much more rapidly than in stiff heavy soils, and consequently the condition of the land will likewise modify the action of this refuse manure. Under the most favourable circumstances, however, shoddy ought to be used in an unprepared state, for the interval between the ingathering of a green crop and the preparation of the land for the corn crop is generally too short to allow the wool refuse to enter into decomposition; its effects consequently are lost upon the crop which it is intended to benefit, and unless a second corn-crop is grown, shoddy will but little benefit the second crop in the rotation, for it is a refuse which owes its fertilising effect almost altogether to the nitrogen it contains, and which furnishes on decomposition ammonia, and as ammonia does not exhibit the same powerful effect on other crops which it does on the cereals, the chief advantages which may be derived from the application of shoddy are lost.

These examples, I hope, will be sufficient to prove the correctness of the remarks which have been made. They are remarks founded on actual facts which have come under my personal notice.

I might easily point out other cases, with which I have become personally acquainted, as bearing on this subject, but this will perhaps be superfluous, and I will therefore merely observe, in addition to the remarks already made, that when all care, attention, and labour have been applied, uncontrollable circumstances often interfere which spoil the experiments in the field.

It affords me, therefore, much pleasure to have the privilege of giving an account of some experimental trials which were made last season, under peculiarly favourable circumstances, on the farm attached to the Royal Agricultural College. These experiments were made on Swedish turnips, with the following fertilisers:—

1. Guano.
2. Mixture of guano and dissolved coprolites.
3. Bone-dust.
4. Home-made superphosphate of lime.

5. Economical manure.
6. Nut-refuse.
7. Dissolved coprolites.
8. Commercial dried night-soil.
9. A mixture of sand, guano, dissolved coprolites, and superphosphate of bones.

The field selected for the experimental trials with these manures was almost perfectly level, and throughout of a uniform depth. It had been cropped alike in every part in previous years, and otherwise uniformly cultivated. The surface soil is shallow, and rests on the great oolite limestone, from which it is separated by a clayey subsoil of small dimensions. Altogether it is a turnip soil of but moderate quality, belonging to the class of calcareous soils, as will be seen by glancing at the subjoined analyses.

1. *Mechanical Examination of Soil of Experimental Field, Cirencester.*

a. On passing 24 lbs. of the surface soil through a $\frac{1}{2}$ inch sieve, there were separated:

Large stones, weighing	1 lb. 6 ounces.
Soil, passing through the sieve . . .	22 ,, 10 ,,
	24 lbs.

b. Of the soil passing through the $\frac{1}{2}$ inch sieve, 1 lb. was riddled through a series of 4 perforated zinc cullenders, fitting into each other. The uppermost cullender was provided with apertures, measuring $\frac{1}{4}$ of an inch in diameter; the second with apertures $\frac{1}{8}$ of an inch in diameter; the third was perforated with holes $\frac{1}{16}$ in. diameter; and the fourth with holes $\frac{1}{32}$ in. diameter. By this means it was divided into five different portions, the relative proportion of which was as follows:—

No. 1. On $\frac{1}{4}$ inch sieve were left	121 grains, fragments of limestones.
2. ,, $\frac{1}{8}$,, ,,	643 grains of soil, including a large proportion of limestones.
3. ,, $\frac{1}{16}$,, ,,	2,246 grains.
4. ,, $\frac{1}{32}$,, ,,	1,192 ,,
5. Through the last sieve passed	2,882 ,,
	7,085 ,,

A mechanical examination of this description is useful, inasmuch as it enables us to form some idea of the state of division in which the soil-constituents actually occur, and in experimental trials enables the reader to judge for himself whether or not the soil was sufficiently pulverised for the crop experimented upon. It will be observed by these data that the mechanical preparation of the experimental field has been carefully attended to.

c. The portion collected on the first sieve consisted entirely of fragments of limestones, and that of No. 2 nearly altogether of similar but smaller fragments. Both were rejected in preparing a fair average sample for chemical analysis, and the portions from Nos. 3, 4, were powdered in a mortar, passed through the $\frac{1}{32}$ inch sieve, and mixed with No. 5.

Before submitting it to chemical analysis, the average sample was separated by washing into the following portions:

100 parts of average soil contained—

Organic matter and water of combination	. . . .	6·339
Burned deposit after standing 5 minutes	. . . .	69·600
" " 10 "	. . . .	3·880
" " 15 "	. . . .	3·230
Remaining in suspension after standing longer than 15 minutes	. . . .	16·951
		100·000

The first deposit consisted of a calcareous sand, whilst the second and third were coarse clay, and what remained in suspension fine clay.

The general composition of the soil can therefore be expressed as follows:—

Organic matter and water of combination	6·339
Clay	24·061
Calcareous sand	69·600
	100·000

2. *Chemical Examination.*

On analysis of the average sample prepared as described above, the following results were obtained:—

100 parts contained—

Organic matter and water of combination	6·339
Oxides of iron and alumina, with a trace of phosphoric acid	9·311
Carbonate of lime	54·566
Magnesia	trace
Sulphuric acid	ditto
Chlorine	ditto
Potash and soda	1·032
Insoluble siliceous matter.	28·947
	100·195

It will be observed that carbonate of lime greatly preponderates in this soil, and that the proportion of alkalies is but small, whilst mere traces of phosphoric and sulphuric acid were found in it. Calcareous soils of such a composition are generally unproductive.

The experimental field was carefully measured out, and divided

into ten different plots of one-eighth of an acre each. These experimental plots were arranged side by side in continuous rows of drills, care being taken to reject the headlands from the experimental plots. The space of one-eighth of an acre was occupied by three rows of drills. The different manures were all applied to the land on the same day; and in order to secure their full efficacy and their even distribution, they were put on the ridges by hand in a groove, made by a hoe being drawn along the top; the different manures were then covered with some soil, and after passing a roller over the drill, all the swedes were sown by ridge-drill on the 20th of June. Subsequently, all experimental plots were treated in precisely the same way, and care was taken to render the experiments in every respect strictly comparative.

One of the experimental plots was left unmanured; the nine remaining were manured in the manner described, with the subjoined quantities of the manures, which have been mentioned already. These quantities of the different fertilisers were obtained in each case with an expenditure of 5*s*., or each experimental plot was manured at the rate of 2*l*. per acre.

Thus to

			Cost, 5*s*. for each Plot.
Plot	I.	was applied	. 56 lbs. of guano.
,,	II.	,, ,,	. 84 lbs. of coprolites, dissolved in sulphuric acid, and 28 lbs. of guano.
,,	III.	,, ,,	. 100 lbs. of bone-dust.
,,	IV.	,, ,,	. 93 lbs. of home-made superphosphate.
,,	V.	,, ,,	. 56 lbs. of economical manure.
,,	VI.	,, ,,	. 120 lbs. of nut-refuse.
,,	VII.	,, ,,	. 140 lbs. of dissolved coprolites.
,,	VIII.	,, ,,	. Nothing.
,,	IX.	,, ,,	. 180 lbs. of commercial dried night-soil.
,,	X.	,, ,,	. A mixture of 1 bushel soot, 30 lbs. of guano, with dissolved coprolites, and superphosphate of bones.

Before stating the yield of each experimental plot, I may be permitted to offer some observations on the condition of the growing crops, and on the chemical composition of the different fertilisers used in these experiments. All have been analysed in my laboratory, either completely, or when a complete analysis appeared superfluous, only those substances were determined on which principally the efficacy of the manure depended.

Plot I. Manured with 56 lbs. of guano, or at the rate of 4 cwts. per acre.
Cost of manure 5*s*., or 2*l*. per acre.

The young plants came up remarkably well, and looked for a considerable time as well, if not better than the rest of the experimental plots. When, however, the bulbs began to swell, it was evident to the eye that the guano turnips would be left

behind by the superphosphate, and probably also by the dissolved coprolites, mixed with guano; and the result has proved that this was actually the case. The guano was best Peruvian, and was bought at the price of 10*l.* per ton. On analysis its composition was ascertained to be as follows:—

Water	12·420
Organic matter and ammoniacal salts	52·980
Phosphates of lime and magnesia (bone-earth)	25·065
Alkaline salts, chiefly chloride of potassium and sodium, with a small quantity of alkaline phosphates and sulphates	8·262
Insoluble siliceous matter	1·507
	100·234
Containing nitrogen	14·177
equal to	
Ammonia	17·215

The guano employed in the experimental trial, as shown by its analysis, was genuine Peruvian guano of good qualities.

Inferior kinds of guano, such as Saldanha-bay and Patagonian, I think, would have given a better result, for they are richer in phosphates than Peruvian; and as the commercial value of guano is principally regulated by the proportion of ammonia it contains or furnishes on decomposition, and as ammonia does not benefit root crops in an equal degree as white crops, whereas phosphatic manures exercise a specific action on roots, which causes them to swell and thus to increase the crop, it would appear that, to the extent to which Peruvian guano is richer in nitrogenized matters than other kinds of guano, it becomes less valuable. Indeed, it appears to me a great waste to apply Peruvian guano alone to swedes or turnips; and I hope to support this opinion by the practical proofs which will presently be mentioned.

Plot II. Manured with 84 lbs. of coprolites dissolved in sulphuric acid and 28 lbs. of guano, or at the rate of 6 cwts. dissolved coprolites and 2 cwts. of guano.

Cost of manure 5*s.*, or 2*l.* per acre.

At first no difference in the appearance of the swedes, when compared with those grown with guano alone, could be observed; but at a more advanced season the roots looked decidedly better than those of Plot I., and, indeed, of most other experimental plots.

The dissolved coprolites were made on the farm by digesting the finely ground, so-called Suffolk coprolites, with one-third their weight of sulphuric acid, and allowing this mixture to become nearly air-dry by keeping. It was then mixed with guano, and thereby obtained in a perfectly powdered and air-dry state.

On analysis the ground coprolites were found to contain in 100 parts—

Hygroscopic water	1·20	
Water of combination, and a trace of organic matter	3·20	
Oxides of iron and alumina	4·84	
Lime	39·81	
Magnesia	5·68	
Phosphoric acid	23·48	equal to 47·82 of bone-earth.
Carbonic acid	5·82	
Insoluble siliceous matter	12·56	
Alkalies, sulphuric acid, and loss	3·41	
	100·00	

The price of the dissolved coprolites made on the premises was 4*l.* per ton. At the present prices of the raw coprolites, the dissolved article would be more expensive.

Plot III. Manured with 100 lbs. of bone-dust, or 7 cwts. and 16 lbs. per acre.
Cost of manure 5*s.*, or 2*l.* per acre.

The swedes on this plot looked healthy, but, it struck me, rather unequal. A distinct difference in the average size of the roots, as compared with the two preceding plots, soon became apparent to the eye when the root began to swell. On analysis the bone-dust was found to contain in 100 parts—

Moisture	18·12
Organic matters (gelatine and fat)	29·29
Phosphates of lime and magnesia (bone-earth)	44·22
Carbonate of lime	5·49
Alkaline salts (chiefly common salt)	1·49
Sand	1·39
	100·00
Containing nitrogen	4·28
equal to	
Ammonia	5.23

Previous to crushing they had undergone no preparation whatever, and contained consequently a great deal of fat, which circumstance explains their slow action. 2*s.* more per quarter was paid for obtaining the bone-dust in a finer state than it is usually sold. A bushel on an average weighed 44 lbs., and the price per ton was 5*l.* 12*s.*

Plot IV. Manured with 93 lbs. of home-made superphosphate of lime, or at the rate of 6 cwts. and 72 lbs. per acre.
Cost of manure 5*s.*, or 2*l.* per acre.

The seed came up well, but at the first stage of growth the swedes sowed with guano appeared somewhat better. At a later period the difference in the appearance of these two plots was less striking; and when the bulbs began to swell, it was

evident that in all probability superphosphate of lime would surpass the other manures in its effects upon Swedes. Experience has proved it to have been the case.

In the preparation of the superphosphate the fine bone-dust, of which an analysis has been given already, was first moistened with one-third its weight of boiling water, and after the water had been thoroughly soaked in by the dust, one-third of its weight of brown oil of vitriol was added. The mixture was made in a wooden trough, from which it was removed and placed in a heap, after it had become sufficiently consolidated. It was made a considerable time before the sowing of the turnips, and had thus time to become thoroughly disintegrated in the heap and dry on keeping. Before its application to the land, it was broken down with a wooden mallet into a fine powder.

Boiling water was found to assist the dissolving action of the oil of vitriol in a very high degree: it can therefore be recommended as greatly preferable to cold water. The cost of the dry home-made superphosphate was 6*l.* per ton.

Plot V. Manured with 56 lbs. of economical manure, or at the rate of 4 cwts. per acre.
Cost of manure 5*s.*, or 2*l.* per acre.

In a very short time after the bulbs had begun to swell, this plot was left behind by all the other experimental plots, the undressed portion excepted. The difference in the appearances between this plot and the other manured plots became more and more striking as the crops approached maturity, when the most unexperienced eye could observe that the economical manure had done little good to the swedes. It was, indeed, impossible to observe the slightest difference between the unmanured plot and the one dressed with economical manure. This unfavourable result cannot surprise any one who knows that phosphoric acid applied in a form in which it can be readily assimilated by the growing plant, more than other fertilizing constituent, benefits root crops, if he throws a glance at the following analysis:—

Composition of Economical Manure.

Water	36.525
Protosulphate of iron (green vitriol)	23·756
Sulphate of lime	·860
Sulphate of magnesia	·204
Bisulphate of potash	4.677
Bisulphate of soda	10·928
Sulphate of soda (Glauber salt)	15·143
Sulphate of ammonia	2·648
Insoluble siliceous matter (sand)	5·850
	100·591
Containing ammonia	·683

This manure, it will be observed, consists principally of crystallized green vitriol and bi-sulphate and sulphate of soda. These sulphates of soda are obtained at a cheap rate, as a refuse in several chemical manufactories. Both the crystals of green vitriol and Glauber salt or sulphate of soda contain much water of crystallization; hence the large amount of water ($36\frac{1}{2}$ per cent.) in a tolerably dry substance. The economical manure has a strongly acid taste and reaction, and might therefore be supposed to contain a great quantity of soluble or acid phosphate of lime; but whilst it contains only about 7-10ths per cent. of ammonia, phosphoric acid is excluded entirely from its composition. We need not, therefore, feel astonished that it produced scarcely any effect upon swedes.

The price at which the economical manure sold last season, and is again sold this season, is 12*l.* per ton. Its constituents can be furnished at about 3*l.* a ton; the manufacture of a manure of the above composition thus might even pay well if sold at 5*l.* per ton instead of 12*l.* per ton, its actual price.

Plot VI. Manured with 120 lbs. of nut refuse, or at the rate of 8 cwts. 64 lbs. per acre.
Cost of manure 5*s.*, or at the rate of 2*l.* per acre.

The swedes upon this plot had as healthy an appearance as any of the experimental plots, and it was difficult to observe any difference in the relative average size of the bulbs of this plot and those of the next and the tenth plot.

This refuse was the powdered cake of an oily nut, probably cocoa-nut. It was submitted in my laboratory by my pupil, Mr. Louch, to a partial analysis, who found in 100 parts—

Water	11·60
Organic matters	79·12
Inorganic matters (ash)	9·28
	100·00

This quantity of organic matter on combustion gave in two experiments—

	1 Exp.	2 Exp.	Average.
Nitrogen	4·826	4·90	4·863

In the 9·28 of ash were found—

Earthy phosphates	4·12
Phosphoric acid, combined with alkalies	·13
Sand and soluble silica	2·42
Alkalies, magnesia, &c.	2·61
	9·28 grs.

It will be observed that this nut-cake manure contains a very large amount of nitrogen, and also a quantity of phosphates and alkalies which is by no means inconsiderable. It was sold in

small quantities at the rate of 5*l.* per ton; but I am told in large quantities it may be had at 3*l.* a ton. At the latter price it certainly is very cheap and well worthy the attention of the farmer, as it is a powerful manure, which, however, is more economically applied to wheat or grass-land than to turnips.

Plot VIII. *Unmanured plot.*

As mentioned already, a very great difference was soon perceptible between this and most manured experimental plots (except the economical plot). The swedes were very small, but otherwise in good condition.

Plot IX. *Manured with* 180 *lbs. of commercial dried night-soil,* or at the rate of 12 cwts. and 96 lbs. per acre.
Cost of manure 5*s.*, or 2*l.* per acre.

No difference in the probable yield of this plot and the next could be observed. Plots IX. and X., however, did not promise so good a crop as Plots I., II., VII., and especially IV.

The effect produced by the dried night-soil was not so great as might have been expected. Pure night-soil is a powerful manure, which contains a considerable proportion of phosphoric acid, and for this reason ought to benefit root-crops in a decisive manner. It must be borne in mind, however, that the dried night soil was a commercial article, which, like many commercial articles, possessed a better name than it was entitled to by its composition. For the preparation of this manure a good deal of water was retained, and no doubt a large proportion of rubbish besides common salt was employed, as will be seen by glancing at the subjoined analysis:—

Composition of Commercial dried Night-Soil Manure.

Water	19·712
Organic matters	17·484
Carbonate of lime	9·229
Magnesia	·168
Oxides of iron and alumina	20·061
Phosphoric acid	4·399
Common salt with some sulphate of soda and potash	11·864
Insoluble siliceous matter (sand and brick-dust)	16·941
	99·858

It was sold at 3*l.* 2*s.* per ton.

Plot X. Manured with a mixture of 1 bushel of soot, 30 lbs. of guano and dissolved coprolites, and bone superphosphate to make up the 5*s.* expenditure.
Cost 5*s.*, or 2*l.* per acre.

Guano, dissolved coprolites, and bone-superphosphate, are of the same description as the materials used for the other experiments.

The soot on analysis was found to contain 3·833 per cent. of ammonia: it was procured at the rate of 6*d*. per bushel.

It having been found on previous trials that it was quite impossible to calculate the yield of each plot by weighing only a small number of roots, the whole produce of each experimental plot was weighed on a weigh-bridge.

The following table exhibits the yield of each experimental plot and the weight of the trimmed roots calculated per acre:—

Table showing the Produce of trimmed Swedes of Experimental Plots of one-eighth of an Acre, and Weight of Crop per Acre.

	Per ⅛ of an Acre.			Per Acre.		
	tons.	cwts.	lbs.	tons.	cwts.	lbs.
Plot I. (Guano) yielded . . .	1	9	7	11	12	56
,, II. (Guano and dissolved coprolites) yielded	1	12	2	12	16	16
,, III. (Bone-dust) . . . ,,	1	2	0	8	16	0
,, IV. (Bone superphosphate) ,,	1	14	2	13	12	16
,, V. (Economical manure) ,,	0	15	2	6	0	16
,, VI. (Nut-refuse) . . . ,,	1	5	0	10	0	0
,, VII. (Dissolved coprolites) ,,	1	9	0	11	12	0
,, VIII. (Nothing) . . . ,,	0	13	0	5	4	0
,, IX. (Commercial dried night-soil)	1	3	0	9	4	0
,, X. (Mixture of soot, guano, dissolved coprolites, and bone-superphosphate) . ,,	1	5	1	10	0	8

The results obtained in these experimental trials are both interesting in a practical and scientific point of view, and I may therefore be allowed to offer a few remarks which are suggested by them. Before doing this, however, a point of some moment demands special notice. It will be observed that the unmanured portion of the experimental field only gave a produce of 5 tons 4 cwts. per acre. The natural inference which may perhaps be drawn from so small a crop is, that the land was not in a proper state of preparation for the turnip-crop, and that, consequently, all the experiments are not to be depended upon; I have shown, however, by the mechanical analysis of the soil on which the experiments were tried, that it was well pulverized, and have been assured moreover by our farm-manager, that the experimental field was in a fit state of preparation for the swedes. The soil, it is true, was naturally poor, shallow, and rested on lime-stone rock, from which it was separated by a clayey subsoil of inconsiderable depth. But far from considering this circumstance as being calculated to vitiate the results of the trials, there is much reason to believe that a soil of such a description is peculiarly well adapted for the making of experiments from which legitimate and trustworthy inferences may be derived. A poor soil, it strikes me, is much better adapted to bring out the full manurial effect of different fertilizers than land in the

highest state of fertility. For the productive powers of soils, let it be remembered, cannot be increased to an unlimited extent; when, therefore, a soil is naturally as productive as it can be under any circumstances, or when by good cultivation it has reached its maximum state of fertility, the addition of the most valuable manure, it is evident, cannot produce any perceptible effect. Under these conditions the best fertilizer would produce no greater effect than an utterly worthless and inexpensive manure. Now the closer a soil approaches this condition the less it is adapted for the performance of experiments with manures, and *vice versa;* land not very productive, or naturally poor, is just in a condition in which the full effects of different fertilizers can be best discerned, and I am inclined therefore to consider the fact of the experiments having been tried on a naturally poor soil as peculiarly fortunate.

A reference to the tabulated statement which has just been given will exhibit very considerable differences in the weight of the bulbs raised by an equal money-value of different manures. Thus whilst 2*l.* worth of home-made superphosphate of lime gave an increase of 8 tons 8 cwts. 16 lbs. per acre, 2*l.* worth of economical manure produced merely 16 cwts. 16 lbs. more per acre than the unmanured portion of the field. Again, it will be observed, that whilst 2*l.* worth of dried night-soil gave only 9 tons 4 cwts. of roots, a mixture of guano and dissolved coprolites gave 12 tons 16 cwts. 16 lbs., and dissolved coprolites alone 11 tons 12 cwts.

These differences are still more strikingly exhibited in the following table, in which the different plots are arranged according to the increase which the various fertilizers employed upon each produced: the table likewise shows the cost at which 1 ton of increase was produced in each experimental trial.

Table showing Increase per Acre, and Cost of 1 *Ton of Increase, in* 10 *experimental trials upon Swedes.*

	Increase per acre. tons.	cwts.	lbs.	Cost of 1 ton of increase. £	s.	d.
No. 1. Home-made superphosphate	8	8	16	0	4	9
2. Dissolved coprolites and guano	7	12	16	0	5	3¼
3. Guano	6	8	56	0	6	2½
4. Dissolved coprolites	6	8	0	0	6	3
5. Mixture of guano, soot, dissolved coprolites, and bone superphosphate	4	16	8	0	8	3¼
6. Nut-refuse	4	16	0	0	8	4
7. Commercial night-soil	4	0	0	0	10	0
8. Bone-dust	3	12	0	0	11	1¼
9. Economical manure	0	16	16	2	9	6¾
10. Nothing.						

(Natural produce 5 tons 4 cwts.)

We thus see that well-made superphosphate was by far the most economical manure in these experimental trials, and the "economical manure" the worst of all; for whilst 1 ton of increase raised with the agency of superphosphate of lime was obtained with an expenditure of 4*s.* 9*d.*, 1 ton of increase raised with "economical manure" would cost no less than 2*l.* 9*s.* 6¾*d.* for the manure.

It is worthy of observation that the land in the preceding year was not manured with farm-yard manure, nor indeed with any manure whatever, and we thus see that with superphosphate alone a better crop of swedes may be raised than with guano. It will be seen that guano produced nearly 2 tons less of swedes per acre than home-made superphosphate, a difference which, considering the small crop furnished by the unmanured land, is considerable. Peruvian guano alone, indeed, should not, as is so often the case, be employed for root-crops, for when employed in small quantities the per-centage of phosphates contained in it is not adequate to enlarge the roots sufficiently, and when used in large quantities it is apt to produce an excess of leaves, which is generally the case with all manures containing like guano a large amount of nitrogenized constituents. Had the experiments been tried on wheat instead of swedes, there can be little doubt but that the results would have been different, and guano, in all probability, would have carried off the palm, for it is on the cereals and upon grass-land that highly nitrogenized manures like guano, soot, blood, &c., produce the most beneficial effects. Next to superphosphate made from bones, the mixture of dissolved coprolites and guano gave the greatest increase, the crop weighing 12 tons 16 cwts. 16 lbs. per acre; whilst dissolved coprolites employed alone furnished 11 tons 12 cwts. per acre. This is an exceedingly interesting result, for it shows that a purely mineral phosphatic manure, even when applied in a form in which it can readily be assimilated by plants, does not produce, at least on a poor soil, so large a crop as a mixture in which a portion of the mineral phosphate is replaced by a manure, which, like guano, is rich in nitrogenized constituents. A small amount of an ammoniacal manure, or a fertilizer rich in organic matters, readily furnishing ammonia on decomposition, appears to be sufficient to secure the assimilation of the mineral phosphate; for it will be observed, by glancing at the experiment in which a mixture of soot, guano, superphosphate, and dissolved coprolites was used, that if the amount of organic fertilizing matters in a mixture is increased at the expense of its phosphatic constituents, the produce will be reduced. Thus this mixture, in which a portion of superphosphate was replaced by soot and guano, both containing much ammonia, or furnishing it on decom-

position, only gave 10 tons 8 lbs., whilst the produce of the dissolved coprolites amounted to 11 tons 12 cwts.

Dissolved coprolites, which follow guano in the above list, virtually produced as great a crop as guano, for the difference of 56 lbs. is not worthy of consideration. Whenever coprolites therefore can be had at a cheap rate, they may be employed as a substitute for bone-dust, provided care is taken to dissolve them properly in sulphuric acid and to mix them with some nitrogenized organic manure.

The nut-refuse gave as nearly as possible the same produce as the mixture in experimental plot No. X., and commercial night-soil follows next in the list. A comparison of the crop yielded by bone-dust with that yielded by bone-dust dissolved in sulphuric acid, will forcibly exhibit the advantages of applying bones in the latter form; for whilst an equal money value of bone-dust only gave an increase of 3 tons 12 cwts., dissolved bone-dust gave an increase of 8 tons 8 cwts. 16 lbs.; or whilst 1 ton of increase raised with the agency of superphosphate only cost 4*s.* 9*d.*, 1 ton of increase raised with bone-dust implied an expenditure of 11*s.* 1¼*d.* The form in which an artificial manure is applied to the land thus greatly influences its action.

On the whole, we may learn from these experiments that the value of different artificial manures for a crop of swedes, and no doubt also for other root-crops, principally depends on the amount of phosphoric acid contained in them in a form in which it can be readily assimilated by the plants. In bone-dust there is much phosphoric acid; but when it is used in an unprepared state, in which it still contains all the fat naturally present in fresh bones, it often remains in the soil for a very long time without readily undergoing decomposition, or that preparation so necessary to bring out its full fertilizing effect. All the experiments confirm the general conclusion which has just been expressed; but more especially the experiment with the economic manure, in which the absence of phosphoric acid was proved by analysis, shows the necessity of applying to root-crops a fertilizer containing a good deal of phosphoric acid. Whatever else the virtues of the economical manure may be, it certainly proved the least economical dressing of all, as it produced only 6 tons 16 lbs. of swedes per acre, or only 16 cwts. 16 lbs. more than the unmanured portion of the experimental field.

In conclusion I will observe that I have carefully determined the chemical composition of the roots of each experimental plot, in so far at least as it appeared desirable in order to form some idea as to the nutritive value of the swedes raised with different manuring matters.

The results of these examinations are embodied in the following table:—

Table showing the Proportion of Water in Swedes grown with different Manures.

Weight of Roots.	Per centage of water.	Average amount of water.
Plot I. Guano.		
a. Large sized root, weighing 2 lbs. 11 ounces . .	88·717	
b. Average sized root, weighing 1 lb. 8 ounces .	87·450	87·667
c. Small sized root, weighing 11 ounces	86·834	
Plot II. Dissolved coprolites and guano.		
a. Large sized root, weighing 1¾ lb.	88·420	
b. Medium sized root, weighing 15 ounces . . .	88·600	88·484
c. Ditto root, weighing 15 ounces	88·434	
Plot III. Bone-dust.		
a. Large root, weighing 2 lbs. 2 ounces	88·034	
b. Medium size, weighing 1 lb. 13 ounces . . .	89·067	88·467
c. Small root, weighing ¾ lb.	87·400	
Plot IV. Superphosphate of lime.		
a. Large root, weighing 2½ lbs.	88·350	
b. Average sized root, weighing 1 lb. 10 ounces .	89·284	88·556
c. Small root, weighing 10½ ounces	88·034	
Plot V. Economical manure.		
a. Large root, weighing 2 lbs. 2 ounces	87·717	
b. Average size, weighing 14 ounces	88·067	87·661
c. Small root, weighing 8 ounces	87·200	
Plot VI. Nut-refuse.		
a. Large sized root, weighing 2¼ lbs.	87·900	
b. Average size, weighing 1 lb. 1 ounce	88·384	88·306
c. Small root, weighing 9 ounces	88·634	
Plot VII.* Dissolved coprolites.		
a. Large root, weighing 2½ lbs.	89·417	
b. Medium size, weighing 1 lb. 11½ ounces . . .	88·117	88·578
c. Small root, weighing 9½ ounces	88·200	
Plot VIII. Nothing.		
a. Large root, weighing 1 lb. 11 ounces	88·800	
b. Average sized root, weighing 12 ounces . . .	87·460	87·803
c. Small root, weighing 5 ounces	87·150	
Plot IX. Night-soil manure.		
a. Large root, weighing 1 lb. 10 ounces	88·917	
b. Ditto, weighing 1 lb. 10 ounces	88·767	88·506
c. Small root, weighing ½ lb.	87·834	
Plot X. Mixture of soot, guano, dissolved coprolites, and superphosphate.		
a. Large sized root, weighing 2 lbs. 5 ounces .	88·841	
b. Medium sized root, weighing 1 lb. 14 ounces .	87·131	87·376
c. Small root, weighing ½ lb.	86·156	

It will be observed that the proportion of water and solid matter is pretty nearly the same in all the roots of the different experimental plots. The differences in the amount of water in roots of different size also are very trifling: generally, but not always, the larger roots were somewhat richer in water.

In the following table the proportion of ash and nitrogen in swedes in natural and dry state is given:—

Table showing the Amount of Ash and Nitrogen in Swedes of Experimental Plots.

	Ash.			Nitrogen.		
	In Natural State.		In Dry State.	In Natural State.	In Dry State.	
				Mean.		
Plot No. 1	1st deter. .	·561	4·98		1st deter. .	2·372
	2nd deter. .	·552	4·40		2nd deter. .	2·457
	3rd deter. .	·641	4·87	·298	Mean . .	2·414
Plot No. 2	1st deter. .	·540	4·67		1st deter. .	2·434
	2nd deter. .	·548	4·81		2nd deter. .	2·401
	3rd deter. .	·512	4·43	·278	Mean . .	2·417
Plot No. 3	1st deter. .	·568	5·20		1st deter. .	2·402
	2nd deter. .	·639	6·37		2nd deter. .	2·355
	3rd deter. .	·655	4·75	·274	Mean . .	2·378
Plot No. 4	1st deter. .	·498	4·28		1st deter. .	2·286
	2nd deter. .	·516	4·82		2nd deter. .	2·181
	3rd deter. .	·589	4·93	·255	Mean . .	2·233
Plot No. 5	1st deter. .	·596	4·86		1st deter. .	
	2nd deter. .	·582	4·96		2nd deter. .	
	3rd deter. .	·558	4·36	·300	Mean . .	2·435
Plot No. 6	1st deter. .	·534	4·42		1st deter. .	2·401
	2nd deter. .	·581	5·01		2nd deter. .	2·348
	3rd deter. .	·576	5·07	·277	Mean . .	2·374
Plot No. 7	1st deter. .	·484	4·58		1st deter. .	2·143
	2nd deter. .	·628	5·29		2nd deter. .	2·459
	3rd deter. .	·554	4·70	·263	Mean . .	2·301
Plot No. 8	1st deter. .	·561	5·01		1st deter. .	2·748
	2nd deter. .	·559	4·46		2nd deter. .	2·793
	3rd deter. .	·627	4·88	·338	Mean . .	2·770
Plot No. 9	1st deter. .	·538	4·86		1st deter. .	2·379
	2nd deter. .	·540	4·72		2nd deter. .	2·545
	3rd deter. .	·498	4·10	·283	Mean . .	2·462
Plot No. 10	1st deter. .	·562	5·04		1st deter. .	2·505
	2nd deter. .	·532	4·12		2nd deter. .	2·592
	3rd deter. .	·654	4·73	·321	Mean . .	2·548

I do not think the variations indicated by these determinations are sufficiently great to entitle us to say that the swedes of one plot were more nutritious than those of another.

On the whole these analyses show that the different fertilizers employed in the experimental trials did not affect the composition of the swedes in any material degree; consequently the question as to the comparative economy of using superphosphate of lime in preference to all the other manures employed in the experimental trials remains simple, and the general conclusions to which these experiments have led are not affected by any differences in the nutritive value of the roots.

VI.—*On the Autumn Cleaning of Stubbles.* By E. E. Agate.

Prize Essay.

Autumn culture is one of the most important questions in agriculture. By attention to this point the tenant is enabled to farm his land to the greatest advantage; to it may be attributed the diminished cost of the turnip-fallow, and the introduction of supplementary crops in our rotations, two of our greatest modern improvements—than which nothing requires a greater display of judgment on the part of the farmer, or a more thorough knowledge of the land he cultivates.

"The theory," says a late agricultural writer, "on which this early culture is recommended is, that couch immediately after harvest is comparatively weak, and has not extended its roots far beneath the surface; but as soon as the crop is removed, and the couch so permitted to grow without obstruction, it spreads rapidly along the surface, and penetrates deeply beneath it, and every week that it is left undisturbed renders its extirpation more difficult and expensive. Tear it up early, and the seedlings are at once shaken out entire from the tender soil; leave it to strike deeper root, and every broken fibre that remains strikes afresh, and gaining strength throughout the winter and early spring, gives the farmer at that busy season the expense of a second fallowing. The advantage of this early preparation is attended with this further benefit, that only one furrow is requisite in May, and the ground not being deprived of its moisture at that season, the turnip-seed is sure to vegetate at once."

The subject therefore may be entered upon boldly, and the test of economy be rigidly enforced. This ought to be applied by every one who pretends to write upon an art or to put theory into practice. It will be our aim to show that there is a saving of time and money by an adoption of the system. What more important operation in agriculture than the eradication of weeds? Will any one affirm that he can grow good crops on foul land? Let it be granted that the first requisites to success are draining and manuring, we do not hesitate to say that clean farming is equally necessary. To begin with the former and to neglect the latter, through want of capital or perseverance, has been the road to disappointment and ruin. We admit the reverse of the picture is true, and an endless amount of labour in fallowing has been incurred through the neglect of judicious draining. Weeds are the insidious enemies of agriculture, and it is to their subtle growth that we ascribe much of the inattention to their extermination. That slovenliness is too often the rule is attested by the state of many farms throughout the country. For want

of the expenditure of a sixpence, whole acres are overrun and rendered irredeemable only by an outlay of many pounds. Manure is lavished, as Mr. Herring has so recently demonstrated. It is not our wish to find fault, but to point out the evil and to prescribe the simplest and most effectual remedy. We proceed therefore to show that the best and surest foundation of *clean farming* is an unremitting attention to the autumn stubbles, and we maintain that the effects of such attention may be seen throughout the course, that it is the way to make the rest of the task comparatively easy, and that the gain will be made apparent by the ameliorated condition of the soil, whereby it requires less cultivation and yields greater crops of superior quality.

Forking up Couch by Hand Labour.—This is done immediately after the corn is carried, beginning with that portion of the fallow where a winter green-crop is to be taken, which should be the cleanest stubble on the farm. This must be looked over carefully, all running weeds and such as cannot be killed by the plough being spudded up and carried off the land. It may be done by men or women provided with forks, followed by boys with baskets who pick off the weeds as dug, and when they have filled their baskets deposit them in heaps at the ends of the lands to be disposed of in the most convenient manner. The expense may vary from 1*s.* to 10*s.* per acre. A friend of ours says, " We think spudding cheapest so long as it can be done for 5*s.* to 8*s.* per acre, after which limits horse-labour must be used. No farmer should be satisfied with the condition of his farm till looking over with spuds after harvest leaves the land clean enough for the plough." This is impossible, however, on heavy land. Where running weeds abound, the methods which are mentioned hereafter are to be preferred; for forking, though the most effectual, is the least economical method of cleaning, and the number of acres to be got over in a day very limited. Great care should be taken that nothing is left in the furrows, for this when ploughed in at a usual depth is not killed, but when the land is opened in the spring is found to remain in full vigour, and is then far more difficult to eradicate. The weeds over which the farmer has to exercise the greatest vigilance are, couch-grass, several species of agrostis, knot-grass, crow's-foot, colt's foot, mint, bindweed, docks, and thistles.

Paring Land by Horse-Labour.—The only method of performing this operation until a comparatively recent period was by fixing a broad share, either circular or triangular, to a common plough divested of its mould-board, or to a skeleton plough; in this way 2 horses on moderately stiff land would pare to the depth of 1½ or 2 inches about 1½ acres a-day. The expense is

5*s.* 4*d.* an acre. The scarcity of labour has since paved the way for the introduction of machinery in agriculture; this has lessened the cost of production, and a demand has been created which is not likely soon to flag. Hence the introduction of grubbers, cultivators, subsoil ploughs, &c. Of these implements there are so many that it becomes almost impossible to judge of their respective merits. Difference in the mechanical state and texture of the soil must rule the farmer in the selection of his implements, and each will bear a relative value proportioned to its suitability to a particular soil. Generally speaking the broadshare will be found to answer best on clay land, whilst tines or points with a lighter frame-work are best adapted to the more friable loams and sandstones. The limits of this essay will only enable us to bring before the notice of our readers a few of the most approved implements.

Subsoil Ploughs.—We believe these to be generally unfit for autumn cultivation. The expense of subsoiling is great, and when once done it will last for many years. From our experience we believe subsoiling should be limited to a deep homogeneous soil of considerable tenacity, and we doubt whether it is advisable to trench or invert the subsoil, except on a long fallow. In the discussion at the meeting of the Irish Farmers' Club, in answer to the inquiries of Mr. Harkness, John Grey, Esq., of Dilston, advocates the practice of subsoiling, but he says his experience was on a strong loam (no doubt a deep one) on the side of the Tweed near Berwick. Mr. Todd deprecates the practice, and declares that he would not on any land plough down couch-grass with the view of smothering it, as, says he, "I am of opinion that the only effectual way is to take it out of the land." We have seen land made so foul by trenching as to require the labour of years to clean it; but we believe that couch may be destroyed by ploughing it in, as in the instance we have quoted above, if the air is totally excluded, but under no other circumstances. The expense of subsoiling may be stated from 16*s.* to 30*s.* or more per acre, according to the stiffness of the soil and the depth attained. The price of Gray's, which received the prize at Lewes in 1852, is 6*l.* 15*s.* At Gloucester the prize was awarded to Messrs. Howard.

Bental's Broadshare.—This scarifier has been so long before the public, and has met with such general approbation, that anything we may say in its praise can add but little to its deserved reputation. There are several sizes. The price of those which take 3 feet of ground is 4*l.* In a heavy loam with 3 horses they will do 4 acres per day; the 6-guinea size will take 4 feet in width; it works more steadily, but is considerably heavier in the draft. We would observe here that we have always found

an implement which takes only 3 horses to go proportionately lighter than one which requires more. In the first case they should be worked abreast (the attachment being by means of "wippons"), and the disadvantage sustained when more than 3 are used, arises from the loss of power through uneven and slack working when more are harnessed abreast.

Biddle's Scarifier.—We have never seen this implement at work. It was described to us as being very hard work for 4 horses, and from what we have said above, we should suppose it too heavy to be profitable. It does its work well, however, entering and tearing to pieces the hardest ground. The price, 18*l.*, is sufficient to deter many from buying it. Messrs. Ransome and Sims' Biddle obtained the prize at Gloucester.

Coleman's Cultivator.—This implement is of strong yet simple construction, and has received prizes at many of our agricultural meetings. It is made of various sizes, and provided with a lever to raise the prongs out of the ground; the more expensive have side levers. They range in price from 7*l.* to 15*l.* according to their size, strength, &c.

Among the pair-horse scarifiers, Hart's and Coleman's, and among the paring ploughs, Glover's and Hill's, may be named as demanding attention. Hart's is admirably adapted to light or sandy land; price 6*l.* 6*s.* The others are rather more expensive. They are calculated to get over from 2 to 2½ acres in a day.

The grubber, scuffler, drag, A, or idgett, as this implement is differently named, always ought to accompany the scarifier, by following which in a contrary direction the weeds are dragged to the surface to be collected afterwards by the harrow or horse-rake. No machinist has yet invented an implement which performs well the two operations of grubbing and scarifying. The grubber in general use is of home-construction. The frame-work is of triangular form, with 7 or 9 strong tines fastened in with bolts. It should be provided with wheels to be raised or lowered as required. Such an one can be made for 4*l.* or 5*l.* All these implements require a continuance of fine weather to insure their working successfully. In light soils the spud may often be substituted, but on heavy land their employment has enabled the farmer to grow good green crops where he would not have attempted it previously.

Disposal of Vegetable Matter.—After having pared the soil and dragged the rubbish into rows, which may be most conveniently raked into heaps by hand, we have to consider the best means of conveying it away. There are three methods which are put into practice in different parts of the country. 1st. To burn the heaps and

spread the ashes. 2nd. To mix lime with the vegetable matter when carted to some convenient spot. 3rd. To cart it to the homestead, where it serves to form the bottoms of the cattle yards. Fine weather is indispensable to the carrying out of the first plan—and given this condition we believe it is the cheapest and most effectual means of destroying all weeds, and therefore the one to be adopted where the soil is not injured by the contact of ashes as a manure. The burning costs about 2*s*. an acre. As the weather is very changeable at this time of the year, the whole of the turnip fallow would scarcely be got over without some rain; in this case we should prefer the application of lime as the most efficient means of destroying vegetable matter and converting it into valuable manure. The last method we deem unsatisfactory, and the expense of carting backwards and forwards would deter us from following it, unless debarred from the other two. Some farmers send men into the stubbles with forks to dig out the patches of couch, which they throw into a cart, convey to a part of the field, and lay in a long heap. Dung is afterwards carted on, and the whole being turned, it is applied to the next crop. This is an expeditious way, but we cannot recommend it, as the treading is detrimental to the land, and the operation could be performed better by the scarifier.

Subsequent Management of Land if kept bare till Turnip Sowing.—We come now to the most important divisions of our subject, to which the former part is only subsidiary. From the immense difference in the descriptions of soil which by the aid of superior cultivation are made to produce turnips, it is impossible to describe a system which is applicable to all; in our present remarks, therefore, we shall give a comparison of different methods on a somewhat tenacious turnip soil, situated on the chalk, and capable of being ploughed with three horses to the depth of 7 inches. We shall afterwards qualify our assertions in the case of very heavy or light sandy land. The following experiment was conducted under the writer's superintendence in the autumn and spring of 1851-52. The autumn of this year was dry and well suited to the use of the scarifier. About 20 acres of stubble were pared with Bental's broadshare immediately after harvest; this was followed by the grubber and harrows to collect the weeds which were finally raked in heaps, burnt, and spread. The land was then ridged, which is done by a single turn of the plough, each furrow lapping over on the whole ground and meeting in the middle. Five of these went to a rod in order to accommodate them to a 7-foot drill. The ground was allowed to lie undisturbed till the following spring,

when the frost having mellowed it sufficiently the ridges were split, for which operation fine weather is indispensable. The grubber, roller, and harrow were then used at discretion. The expense per acre was as follows:—

	£.	s.	d.
Scarifying	0	2	3
Collecting and burning	0	5	0
Ridging up, 3 horses	0	6	0
Striking	0	4	0
Dragging twice	0	2	4
Harrowing	0	1	0
Rolling	0	1	8
	1	2	3

If the ground should open "unkind," it should be allowed to remain longer, or four furrows given to each ridge before splitting it, which would then be the last operation. The land was sown plain, 28 inches between the drills. On 14 acres adjoining, the first ploughing was given about the end of November—the land being ploughed 7 inches deep in two rod stetches. It remained thus until March, when it was ploughed again—the roller and grubber following. It was ploughed a third time and left rolled ready for the seed furrow. The expense per acre, as compared with the last method, was—

	£.	s.	d.
1st Ploughing, 3 horses	0	10	0
2nd do. 2 horses	0	7	0
3rd do. do.	0	7	0
Dragging twice	0	2	4
Harrowing and rolling	0	2	8
	1	9	0
Expense of 1st method	1	2	3
	0	6	9

This gives a balance of 6*s.* 9*d.* an acre in favour of scarifying. We do not wish these figures to be taken as absolute, or applicable to the same soil in different seasons, much more to other soils; but it is as near an approximation to the truth as is possible, and the results may be taken as *generally* correct. We have purposely omitted the manure and expense of sowing either with or without a ploughing in order that the comparison may be more perfect.

On a few acres that were not so foul the land was ridged up without scarifying—the couch was picked off at little expense when the ridges were opened in the spring, and it was left in good condition by one ploughing and one half-ploughing.

The crop of turnips was best on that portion which was ploughed three times, but this superiority might be attributed to earlier sowing and to the manure, which was dung and artificial; the other pieces receiving artificial alone. On the former there were about 20 tons, on the latter 15 tons. The land was decidedly in the best order where it was scarified and afterwards furrowed up. That which was scarified and ploughed plain was in worse condition than that which was merely ridged up. It must be stated that the spring was wet, and we were unable to work the land properly on the stetches without "poaching," whereas the horses walking abreast in the furrows between the ridges was not injurious to the soil. This is a great advantage of the ridge system on stiff soil. Some farmers in Suffolk prefer narrow stetches adapted to the size of the drill, complaining that the ridges are often dry and cloddy in their arid climate, but we have never found them open to this objection, provided the ridges are ploughed down and the turnips drilled on the flat. From its numerous advantages we believe the Essex ridge-system is gaining ground.

The successful practice of the Messrs. Outhwaite, in the North Riding of Yorkshire, as described by Mr. Caird, may be taken as a type of the system followed on the strong turnip soils of the North and Midland counties of England. "The great aim in the culture of the farm is the early preparation of the land intended for the turnip crop; to this all other work is postponed after the corn crops have been secured in autumn. The stubbles are then stirred in one direction by Biddle's scarifier, the sharp pointed tines being used in this operation, and the ground torn up to the depth of 5 or 6 inches. After the field has been gone over once, the scarifier is fitted with the broadshare tines, and made to cross the former, stirring at right angles, thus tearing the ground to pieces, and disengaging the stubble and roots of weeds and couch, which are drawn together on the surface by the harrows, then gathered by the horse-rake, and laid in a heap to be carried home for littering the cattle yards. The land, now thoroughly pulverised, is ploughed with a clean deep furrow, and in that state is left exposed to the influence of the weather till spring, when it receives one furrow more, and is found in fine condition for vegetating the seed of the turnip crop. The swedes are sown on the ridge 28 to 30 inches apart." The expense of this system is similar to that of which we have given an outline.

On a stiffer clay than that of which we have been speaking, and in a moist climate, we deem the Northumberland system best adapted, viz. one deep ploughing in autumn, and the ground

raised in ridges 27 inches apart early in the following spring upon which the turnips are sown.

On some light lands the improvements have not been so great as on the less easily cultivated soils. We are satisfied that the plough is used where the grubber or scarifier should be introduced, because the work might be done more cheaply and more effectually by these. Norfolk is perhaps a pattern in this respect. Bacon says, "Light lands are ploughed as little as possible, because experience has proved that the less weak soils are exposed to the action of the air in dry weather, the less is the exhaustion of their producing powers." Too much publicity cannot be given to Mr. Milward's statement in the Society's last Journal. Glover's paring plough was used, followed by a single ploughing in autumn; the ground left till May, when it was harrowed with light harrows once and the turnips drilled 30 inches wide. A considerable portion of the crop is valued at 30 tons per acre. The expense of cultivation could not have been more than 15*s.* Admitting this to be an exceptional case, it shows what may be done when the land is in good heart and free from running weeds. Once get your land clean and there is no great difficulty in keeping it so. What a contrast does this present to the old method of two, three, or four spring ploughings (by which if you destroyed weeds you injured your land) at an expense of 3*l.* or 4*l.* per acre! We are aware that the stringency of leases in many instances has been a bar to the introduction of improved methods of cultivation. Happily this hindrance has been generally removed.

We have refrained from saying anything on the application of manure, as the subject is sufficiently important to occupy a separate paragraph. So long since as the publication of Mr. Rham's 'Dictionary,' autumn manuring was esteemed of considerable importance. We there read, "The quantity of manure put on in autumn, or very early in spring, depends on the means of the farm: if 10 cubic yards of short dung can be afforded per acre, the turnip crop will amply repay it, and 20 bushels of bone dust (or less) will be sufficient to drill with the seed. Long fresh manure may be safely ploughed in before winter, which would be very improper in a light soil if used in the summer. This will be rotten before the turnips are sown, and all the expense of forming dunghills and turning them will be saved." Since that time the practice has been greatly extended; it is no longer now confined to the leading farmers, but is fast spreading as a general custom through the principal counties of England. It is undoubtedly a great improvement on the old method; for, who has not had his turnip season seriously damaged

by the treading at that late period, or the sowing indefinitely driven off and sometimes entirely prevented? From 10 to 15 loads of long dung is sufficient if artificials are sown with the seed; the latter are usually bones, superphosphate, and guano: from 8 to 12 bushels of the former, and from 1 to 2 cwt. of the two latter. A large dose is necessary if artificial is used alone. Bones are best for light, guano for heavy land. Superphosphate holds an intermediate position. The writer has seen the largest crops grown with farm-yard and artificial manure combined. Of all manures guano gives the best return for the original outlay. Ashes are a valuable manure for the turnip crop, but they are chiefly important as forming an excellent medium for the application of artificials in the drill. In Essex the earth is dug and burnt for 8*d.* a cubic yard.

Subsequent Management if a Winter, Green, or other Crop be employed.—On stiff soils of moderate quality there is seldom any gain from introducing a secondary crop between the wheat and turnip crop. This is the reason, probably, that one seldom meets with a "stubble" crop except tares on this description of land. On the stronger clays and more easily cultivated and sandy soils, intervening crops may be taken with advantage when judiciously farmed. On the former, one crop, which may be either ersh turnips, rye, tares, trifolium, or rape, is all that can be expected consistently with clean farming; on the latter early peas, potatoes, or a combination of several of these, may be introduced.

The land intended for tares should be ploughed with a clean furrow, about 3 inches in depth, harrowed by two or more turns of the harrow, and rolled if not sufficiently fine. Tares should be sown immediately after the plough, from 2 to 2½ bushels per acre, according to the quality of the land, and 1 peck of rye, beans, or oats, which assists in keeping them from the ground. If intended for soiling horses and cattle, they should be sown in September; if to be fed off by sheep, fortnightly sowings may be made until the second week in November. In the former case we think 10 or 12 loads of good manure would have a better effect on the wheat stubble than if applied in the spring, but it must depend upon the time at the farmer's command.

The writer recollects seeing a very fine piece of tares grown without any manure, and cut for the horses and cows in the yard. The land was then manured with 12 loads of well-rotted dung per acre and ploughed with a thin furrow, everything being carefully buried by means of a skim coulter attached to the plough. It was rolled with a two-horse roll, pressed, and harrowed fine, and turnips of the green round variety drilled immediately with 1 lb. of ashes and 1 cwt. of superphosphate per

acre. The fly attacked them, particularly on a part which was allowed to lie one day before drilling, but sufficient plants were saved, and the weight was valued at upwards of 20 tons.

	£.	s.	d.		£.	s.	d.
Cost of tillage for tares ..	0	12	0	1 acre tares, 6*d.* per rod ..	4	0	0
,, seed	0	14	0	20 tons turnips, 6*s.* per ton	6	0	0
,, tillage for turnips	0	12	0				
,, manure, &c.	3	10	0		£10	0	0
				Expenses	5	8	0
	£5	8	0				
					£4	12	0
				Produce of crop on fallow	3	5	0
				Balance in favour of winter green crop	£1	7	0

	£.	s.	d.		£.	s.	d.
Bare fallow for turnips ..	2	0	0	Supposed crop of turnips, at most 25 tons, at 7*s.* per ton	8	15	0
Manure, &c.	3	10	0	Expenses	5	10	0
	£5	10	0				
					£3	5	0

Failures will sometimes take place, however; and the next year, on the same farm, in attempting to fold off the tares, the lambs were injured, and a very poor crop of turnips was obtained. This was partly because the tares were not fed off soon enough; and it is very probable, if some of them had been ploughed in, the succeeding crop would have been better. Rye on strong heavy soils should never be sown without manure; from 10 to 20 loads of long dung is an excellent preparation. Three bushels is the usual quantity of seed drilled, and it is ready to be mown for the horses about May, and sometimes earlier. It is not quite so valuable a crop as tares, but, coming off sooner, the land can receive several ploughings, harrowings, and rollings, in preparation for a crop of swedes; and we saw last year 12 or 13 tons grown without artificial manure when treated as we have described. This was an unfavourable season; and we think a little artificial might have made it an average crop. Crosskill's clod-crusher is indispensable on such land for reducing the clods to a proper seed-bed; without this implement turnips could not be obtained after a winter green crop.

It has been very difficult to get a plant of trifolium within the last few years. Wet summers, against which the best farmers cannot contend, have harboured so much vermin, that the industrious agriculturist has been compelled too often to compare his fields to those of the Egyptians in the days of Pharaoh. On

account of its value as a feeding crop, many still persist in sowing trifolium, for, if it fails, tares may be drilled on the old furrow. 18 to 20 lbs. of seed are sown after the harrows, and covered in by a heavy roller, Crosskill's clod-crusher following as a preventive against the slug. Lime is also used, but it is of little use, except it be sown when the creature comes forth to feed. The feeding value of trifolium we place fully as high as that of tares. Both this and rye will well repay the farmer as a substitute for a bare fallow. Rape, mustard, and ersh turnips have yet to be mentioned. They are sown on the land which will best bear feeding off. One cwt. of superphosphate or guano will never be lost on them. Although large crops cannot be expected, we are satisfied that they are remunerative when, as we have seen, a small piece of 6 acres, close to the sheep yard, with the aid of a little hay and chaff, has kept a flock of 500 ewes during the most trying part of the lambing season. What would have been the loss of health and comfort to the ewes if they had been driven perhaps a mile to their feed! or what the expense if turnips had been carted to them! In speaking of light land it will be unnecessary to go over the ground which has so lately been traversed and ably described by the authors of the essays on 'Surrey' and on 'Cropping and Cultivating Light Land.' The methods of growing either of the preceding crops are slightly varied from what we have described, having particular reference to the required end—a moist and firm seed-bed. The cultivation is less expensive; the growth of intervening crops less uncertain in its results, and therefore more profitable. Turnips are grown with one ploughing after rye.

We shall confine ourselves, then, to a statement of facts where two crops are taken previous to the turnip crop. We are indebted to a gentleman for the following, in answer to our inquiries:—"The only novelty I have is my experience on 20 acres of good warm loam in 1847. Wheat was carted August 3rd (everything can be done after an early harvest, nothing after a late one). Pomeranian turnips were drilled immediately, and fed the latter end of January. This was followed by peas (early Warwicks), which were sown March 14th after a slight dressing. The frost prevented their being put in earlier. The peas were carried August 20th, and Pomeranian turnips sown immediately, which proved an excellent crop."

A double crop—rye and tares—is also taken on forward lands, and has been known to answer well.

On some of the early loams of Lancashire a crop of early potatoes is obtained before the turnip crop. Mr. Caird says:—"The seed is prepared about the beginning of the year, by being sprouted under cover, and planted out into beds as soon

as the weather permits. The land is very heavily manured, and great care is taken to preserve the young shoots unbroken. Swedes are afterwards transplanted, and excellent crops occasionally obtained in this way." We have no experience of this practice, but we think it must be remunerative.

These feats of agriculture cannot be performed, except under the most favourable circumstances ; but no farmer should lose an opportunity of making his land produce the maximum of bulk with the minimum of expense of which it is capable ; and we know of no way in which these opportunities may be increased so well and so cheaply as by autumn cultivation.

In conclusion we must say that the limits of this essay have not enabled us to exhaust the subject, for instances might be adduced from every part of the country in favour of the "autumn cleaning of stubbles." It has not been our task to add much to the stock of information already accumulated ; but, in attempting to reduce this to general principles, we hope we have not laid ourselves open to the charge of dogmatism. We have given the practices of the best farmers as far as we know, and have pointed out to the best of our ability the conditions under which they may be followed: knowing that no rule can be laid down applicable to all cases, we leave it to the judgment of each to discern how far they may be adopted on a particular farm. We take as a proof of the utility of the system the rapidity with which it has spread. So recently as the year 1847, Mr. Pusey (whose mind is ever on the alert for the advancement of agriculture) had to call the attention of agriculturists, the 'South-country farmers' more particularly, to the 'Autumn Clearing of Stubbles on Light Land,' as described by Mr. Raynbird.* We venture to assert there is not a farmer of local notoriety in the south of England, and we may add in any of the arable districts of England, who, in the year 1855, does not possess some implement for autumn cultivation.

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* Report of Suffolk, Vol. VIII. Society's Journal.

VII.—*On the Advantage and Use of the Aneroid Barometer in ascertaining Heights.* By Nicholas Whitley.

The physical features of all countries greatly influence the productions of the soil; chiefly in governing the climate of the lands situated at various elevations, but also in respect of the facility afforded for irrigation, and the means for the transit of produce.

So conscious are most agricultural writers of this fact, that a description of the agriculture of any district is generally prefaced by a sketch of its physical geography, often too meagre and indefinite. This defect arises in most cases from the difficulty of obtaining the relative heights above the sea of the various prominent points of the district. The operation of levelling even with the favourite "Dumpy" is slow and expensive, and requires a practised eye and a previous training.

The object of this paper is to point out a simple and rapid mode by which the relative heights of a country may be ascertained, and described with sufficient accuracy for all agricultural purposes.

The mercurial barometer has long been applied to the measurement of altitudes, but the newly invented Aneroid Barometer is at once so cheap, portable, and practical, can be used with such facility, and with such comparative accuracy in the results, that it offers the most ready and expeditious method of obtaining the relative elevations in order to an accurate description of the country.

I was enabled in a day's travelling by coach and rail to determine the chief elevations of the land from Truro to Plymouth, Exeter, Wellington, and the Blackdown hills; and on the following days, of the high lands of North Devon and Exmoor; and this without any additional labour or expense, but by observations which tended to relieve the tedium of travelling.

I am induced, therefore, to recommend the use of the Aneroid to those who may hereafter describe the features of any district, and I shall here venture to give the result of my experience with this instrument for their guidance.

The datum should in all cases be the mean level of the sea, or some point above it whose height is known; as a railway station, canal lock, surveyors' bench-mark, &c.

The instrument should be kept as near as may be at the same temperature, read with the dial horizontal, first at the datum, then at the several points where the heights are required, and again on returning to the datum to ascertain if there has been any alteration in the atmospheric pressure; if so, it must be distributed over the stations in accordance with the times of observation.

The following example, by which the height of a meteorological station and other points were determined, will show the manner of using the Aneroid :—

Number of Station.	Places.	Reading of Aneroid.	Correction for variation of Pressure.	True Pressure.	Difference of Pressure between Datum and Station.	Corresponding feet in height above Datum.
1	Datum, lowest step of Parade, Truro, 15 feet above mean sea-level	29·83	..	29·83	..	..
2	Michell Hill Gate	29·62	+·01	29·63	·20	190
3	Road at Buckshead Cottage	29·50	+·02	29·52	·31	294
4	Road over Buckshead Tunnel	29·54	+·03	29·57	·26	247
5	Penmount Gate	29·45	+·03	29·48	·35	332
6	Penmount House	29·47	+·04	29·51	·32	304
4	Again returning	29·51	+·05	29·56	·27	256
3	Again returning	29·47	+·05	29·52	·31	294
7	Turnpike-road north of Lambessa	29·53	+·06	29·59	·24	228
1	Datum on returning	29·76	+·07	29·83	..	..

To each of which 15 feet must be added to give the heights above mean sea-level. No. 4, by accurate levelling for railway purposes, is 251 feet above the datum. Two other independent observations of the Aneroid gave for No. 7 respectively 230 and 235 feet above this datum, showing how nearly the barometer approximates to the truth.

The following table of elevations has been computed, answering to the corresponding depressions of the barometer :*—

Height of the Barometer.	Feet.	Height of the Barometer.	Feet.	Height of the Barometer.	Feet.
Inches.		Inches.		Inches.	
30·0	..	28·6	1,315	27·2	2,692
29·9	92	28·5	1,411	27·1	2,793
29·8	184	28·4	1,508	27·0	2,895
29·7	276	28·3	1,605	26·9	2,997
29·6	368	28·2	1,702	26·8	3,099
29·5	462	28·1	1,799	26·7	3,201
29·4	556	28·0	1,897	26·6	3,304
29·3	650	27·9	1,996	26·5	3,406
29·2	744	27·8	2,095	26·4	3,511
29·1	838	27·7	2,194	26·3	3,615
29·0	933	27·6	2,293	26·2	3,719
28·9	1,028	27·5	2,392	26·1	3,824
28·8	1,123	27·4	2,491	26·0	3,926
28·7	1,219	27·3	2,592	25·0	5,000

* Manual of the Barometer, by J. H. Belville.

The result of this Table seems to be that, for practical purposes, the ratio of 1 degree or inch of the barometer to 1000 feet of elevation may be taken as a mean proportion at ordinary elevations.

The most favourable time for using the Aneroid is when the air is still and uninfluenced by disturbing causes, as a change of pressure or of temperature would produce corresponding errors when only one instrument is observed. But a very near approximation to the truth may be obtained by the use of two barometers which have been compared and adjusted; the stationary one should be read every hour, while the other is in the field, and the usual correction for temperature applied.

By this simple instrument, aided by the railway sections which intersect the kingdom, the physical features of any country may in a short time be accurately determined, and a better knowledge obtained of its climate as influencing its agricultural capabilities and prospects. NICHOLAS WHITLEY.

Truro, 31*st May*, 1854.

NOTE.—The aneroid, to be really useful, requires to be in the hands of persons aware of its liability to mislead, and knowing, like Mr. Whitley, how to guard against this. All aneroids, like mercurial barometers (though from another cause), do not move at the same rate. 174, 172 are mercurial reductions, corresponding to 194, 212, 198, and 222, given by aneroids, taken from A to B and back to A again, the real height being 172. Another simultaneous pair were 2017 and 1817, another pair 1772 and 1690, off different instruments. Readings taken on a journey are very amusing, but they must, as Mr. Whitley's example shows, be counterpoised by a return journey. The same height, in a recorded observation in MS., came out 148 in the morning journey and 415 in the afternoon return journey. But the correction for barometric variation brought the first to 373 and the second to 370. Two careless observers would have respectively struck by the 148 and 415, or condemned their instruments.

The same aneroid will also work at a different rate under different degrees of barometric pressure, and the more careful makers endeavour to get its action most perfect in that part that is most likely to be used. From some unexplained cause, the same aneroid has worked at different rates at one time from what it has at another, and they are liable, with sudden jerks, to shift their whole reading permanently to the extent of $\frac{1}{10}$.

The Table extracted from Belville's work was computed by him on the supposition of the thermometer being at 55°. Galbraith's Tables, costing only 2*s*., should be in the hands of all who wish to use the barometer for determining heights carefully. Following the best formulæ, his Tables are computed for freezing-point, and a table of corrections given for the temperature of the air. Upon a height of 1000 feet the correction might easily be in a sharp frost a *subtraction* of 10 feet, or an *addition* of 100 feet in a hot summer's day.

Notwithstanding the above remarks, the aneroid is a most interesting companion; but it is not too much to ask that those who do not know how to guard against mistakes in the use of it will be very careful not to put out as accurate or trustworthy the simple results of its uncorrected readings at the rate of 1000 feet to the inch.—*Remarks by Mr. Troyte.*—T. D. ACLAND.

VIII.—*On the Agricultural Relations of the Western portion of the Hampshire Tertiary District, and on the Agricultural Importance of the Marls of the New Forest.* By Joshua Trimmer, F.G.S.

General Description of the Strata of the District.—The district to which the following remarks apply extends from the Southampton Water nearly to Dorchester. In existing geological maps it is laid down as London and plastic clay. The recent researches of Mr. Prestwich have proved, however, that little of it belongs to those formations, and that the greater portion consists of sands and clays, which are the equivalents of the Bagshot sands of the London district. He has thus established the true place of the Bagshot sands in the tertiary series. From the absence in the London district of the freshwater beds of the Isle of Wight, this had previously been misunderstood. The place of the Bagshot sands is now proved to be intermediate between the Freshwater deposits and the London clay. The freshwater, or more properly fluvio-marine strata of the Isle of Wight, which I shall call the Upper Eocenes, cover a much larger area north of the Solent than is shown on any geological map yet published. They extend from near the Southampton Water to Hordwell, on the coast, forming a triangular district in the interior, with its apex a little north of Lyndhurst, and traversed through its centre by the Dorchester railway, which enters it near Denny Lodge, in the New Forest, and quits it a little west of the Christchurch station. The Middle Eocenes, consisting of the Upper, Middle, and Lower Bagshots, form a belt which surrounds the above triangular area on the east, west, and north, and which is consequently twice crossed by the railway. It is crossed on the east between the Southampton Water and Denny Lodge, before mentioned as the eastern commencement of the freshwater marls—on the west between the Christchurch station and Dorchester. With respect to the subdivisions of these Middle Eocenes, since the strata have a slight rise eastward, as well as northward and westward, the lower part of the Middle Bagshots (the Bracklesham sands) is first crossed by the railway between Southampton and Eling. The Barton clay, which forms their upper part, succeeds from Eling to the Ashurst Lodge. The Upper Bagshot sands come next in the order of succession, between that point and Denny Lodge, where they are covered by the freshwater marls. They emerge again from beneath these a little beyond the Christchurch station, and continue to the valley of the Avon, near Ringwood. The Barton clay crops out in the eastern escarpment of that valley. The Bracklesham sands have been denuded and covered

with superficial deposits along the greater portion of the valley, except in Hengistbury Head and St. Catherine's Hill.

The Lower Bagshot series commences on the western side of the Avon valley, and extends to within two miles of Dorchester. Between the termination of these strata and the chalk a narrow band intervenes, consisting of the Lower Eocenes, or London and plastic clays. In their range, westward from the Isle of Wight, these have thinned off considerably, and have lost much of their argillaceous character. The London clay too, which is generally full of fossils, has ceased to be fossiliferous. The area occupied by the Lower Eocenes is very irregular, varying in width with the amount of disturbance by which the chalk has been affected, from less than 200 yards to nearly 2 miles.

The white clay, worked so extensively between Poole and Corfe Castle, is not a member of the plastic or mottled clay series, but occurs in irregular beds just above it, in the lower part of the Lower Bagshot sands.

Characters of the Soils on the different Strata when free from transported matter.—These different members of the Eocene tertiaries yield, when their surface is exposed, soils of very different characters. They are covered, however, through a great portion of the district, by other more recent deposits, which are disregarded on geological maps, but which modify considerably the agricultural characters of the strata on which they rest.

We will first consider these characters in the uncovered state of the strata as they occur among broken ground and on steep escarpments. Under these conditions the Upper Eocenes, or freshwater clays and marls, yield cold and wet soils, capable however of considerable improvement by draining and good cultivation. The characters of the Upper and Lower Bagshot strata are, under similar circumstances, nearly alike, producing coarse and loose siliceous sands, which in some cases have an absorbent, in others a retentive base, as they happen to rest upon beds of sand or clay. Strong soils are however seldom of great extent on these strata. The greater portion of the country which they occupy consists of wide-spreading sandy wastes, covered with heath and furze, their dreariness partially relieved by extensive plantations of pine and fir. The fir tribe, however, have often been planted where a little geological examination might have taught the planters that the oak would flourish. At a depth below the surface accessible to the tap-root of the oak, beds of clay and sandy clay frequently occur. To a practised eye their existence becomes evident before they are exhibited in sections, by the vigorous growth of the oak when it has become accidentally established among the firs.

In the district which I have examined there is not a sufficient extent of the Barton clays and Bracklesham sands of the Middle Bagshots uncovered by superficial deposits to demand any notice of their agricultural characters.

The Lower Eocenes (London and plastic beds) are distinguishable by the most cursory observation as forming a zone of cultivated and wooded country, which borders the Middle Eocenes, and contrasts strongly with their dreary wastes. This superior fertility arises from a different arrangement of their argillaceous and arenaceous constituents. The sand and clay, instead of being in separate beds, are more intimately mixed, and the sands are of finer grain. They consist, in the upper or London clay portion, for the most part of fine sands, clayey sands, and sandy clays, or brick-earth, passing downwards into strong clay resting upon sand, and frequently containing bands of argillaceous iron-stone. The beds of clay, particularly where ironstone abounds, yield, when exposed on the surface, soils anything but fertile. The Lower Eocenes also contain, locally, beds of coarse siliceous sand and sandstone, which afford soils as sterile as any portion of the Middle Eocenes or Bagshot series.

The base of the whole tertiary series is the plastic or mottled clay, in which red, yellow, and plum-colour are the prevailing hues. It seldom exposes a wide surface in the area under consideration. A band of sand only a foot or two thick, with large oyster-shells (*Ostræa bellavocina*), separates it from the chalk. This band has been found, by Mr. Prestwich, to expand, in the tertiary district east of London, into a series, which he has named the Thanet sands.

Modifications produced by the superficial Deposits.—Such is the general nature of the different members of the Eocene tertiaries of this district, and of the soils derived from them in their normal state ; but their agricultural characters have been considerably modified by the covering of those more modern deposits before alluded to as having been spread over them. From the general absence of marine remains, the age of these superficial accumulations admits at present of a doubt.

In many respects they resemble the upper erratic tertiaries north of the Thames ; but, as the boulder clay, or lower erratics —the epoch of which is defined by its superposition to the mammalian crag of Norfolk—does not occur in the Hampshire district, we cannot be certain whether the most modern tertiaries of the south belong to any portion of the erratic period until they shall have been traced so far northwards as to enable their relations to undoubted erratic tertiaries of the pleistocene era to be ascertained.* They consist of beds of flint gravel, little water-

* Six years have elapsed since this passage was written. In consequence of

worn, and of the wreck of the eocene tertiaries. They occur at heights varying from the sea level to 600 feet above it. The gravel varies in depth from 2 and 3 feet to more than 20. It is found on the summits of some of the chalk hills (Purbeck Hill), on the denuded surface of the lower eocenes (Bere Hill), at lower levels than these, on the tabular hills of the lower and middle eocenes through the whole of the tertiary district under consideration; and it forms terraces in the valleys of the principal rivers, from 20 to 30 feet above the level of the alluvial flats which border their streams. In the Isle of Wight this gravel occurs on the summit of Headon Hill and on the high grounds near Osborne House.

The flints of which it is composed are of the largest size when found at the greatest elevation. There is a diminution of size with every stage of descent. Little increase, however, of abrasion accompanies this diminution of size, and the slight degree of wear seen in the gravel of the terraces bordering the rivers contrasts strongly with the rolled and smooth condition of those flint pebbles which form occasional beds in the eocene tertiaries.

This slight abrasion of the newest tertiary gravel of the south is an important fact difficult of explanation, if we suppose, which seems probable, that the detached masses which cap the highest hills once formed a continuous stratum over the whole area; and that its materials have been removed by denudation to lower levels. It would seem to indicate that the movements of elevation to which the denudation is to be attributed took place rapidly. The gravel is covered, and frequently replaced, by a loamy deposit, analogous to that which, in a paper on the geology of Norfolk, I have called the warp-of-the-drift.*

Its depth and composition vary with the contour of the surface, and with the nature of the strata exposed in the vicinity. On the chalk it is much more common than beds of gravel. It is evident, from the presence of outliers, or detached masses, of the eocene tertiaries, that they once extended far beyond the present limits of the main body.

To the wreck of these strata and of the chalk we may refer much of the matter of which the warp-drift is composed. Beds of clay, loam, and sand, mixed with large flints, are met with

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researches which I have since made in other localities, I am now able, with some degree of confidence, to identify the gravel south of the Thames, with the latter portion of the upper Erratic period. See Quarterly Journal of the Geological Society, vol. viii. p. 286.

* For more recent investigations respecting these deposits see papers by the author in Quarterly Journal of the Geological Society, vols. vii. p. 19, 31, 20; viii. p. 273, 282, and 286; also Sir R. Murchison, ibid. vol. vii. p. 349.

high on the chalk hills, of such a depth that, in the absence of good sections, they may be mistaken for outliers of eocene tertiaries. When the internal structure is laid open in sections their true nature is shown; and it becomes evident that they have only slight remains of the eocene strata beneath them, generally filling pipes and hollows in the chalk. This warp-drift, or loamy and clayey covering, constitutes the "red land" of the farmers of the chalk. That it is an aqueous deposit, composed of the mixed materials of several strata, and not the residuum left by the gradual solution, as some suppose, of the calcareous matter of the chalk, by existing atmospheric agencies, may be inferred from the alternations which it frequently contains of materials derived from different quarters. The same conclusion may be drawn from the fact that in its lower part it frequently contains fragments of chalk, which ought not to have escaped solution by the agencies which are supposed to have dissolved the surface of the chalk-rock on which it rests.

In some situations finely comminuted detrital chalk abounds so much as to produce white calcareous loams resting upon chalk.

We have thus upon the chalk, within very short distances of one another, a greater variety of soils, calcareous and non-calcareous, than could possibly have resulted from any probable variation in the composition of the rock itself. These soils, therefore, could not have been derived wholly from it.

On level surfaces and gentle slopes this warp-drift is deep, and somewhat homogeneous in its composition, forming loams of various degrees of tenacity.

On the summits of many of the tabular hills of the eocene tertiaries the gravel is covered by a film of this loam, less than a foot deep. On the gravel of the terraces bordering the rivers it is several feet in depth, and constitutes, in conjunction with the alluvial flats nearer to the streams, fertile oases amidst the surrounding desert heaths. Even amidst those wastes, on widely-extending level surfaces, in hollows, and in gentle slopes, there is a loamy covering, proved to be susceptible of cultivation by the state of those portions which have been reclaimed. The difference between the Ordnance maps, which have been made forty years, and the present state of the ground, proves that cultivation has been slowly advancing in the interval.

On steep escarpments this loamy covering is almost wholly absent; and among broken ground it often assumes the form of an irregular mixture of flints with loam, sand, and clay, such as could not, under any circumstances, have been derived solely from the bed on which it rests, but must have required a swish of water for its production.

The irregular indentations at the junction of this deposit with the subsoil, or with the stratum on which it rests, considerably embarrass the operations of draining, when the indentations have been formed in tenacious clay. They are probably the principal cause of the discrepancies of opinion which prevail respecting the superior efficacy of deep or of shallow drains.*

From the combined influence of the most modern tertiaries, the warp-drift, and the eocene tertiaries, there result a great variety of soils, reducible to three classes—1, clay, and clay loams; 2, sands, gravels, and sandy loams, on a retentive base; 3, sands, gravels, and sandy loams, on an absorbent base. The improvement of the first class is to be sought in effectual draining and subsoiling, in conjunction with the use of lime, or chalk, or burnt clay. The improvement of the second class must consist in draining, subsoiling, and the addition of chalk or lime, or of marl and clay unburnt. For the improvement of the third, the chief requisite is the addition of chalk, clay, or marl. The liberal use of organic manures is, in each case, presumed.

Mineral Manures.—Mineral manures are by no means wanting in the district. In the gault and greensand, which crop out on the western side of the chalk range, and in the Purbeck oolites, there are some valuable beds of marl; but the intervention of that steep ridge renders them by no means accessible to the tertiary strata on its eastern side. Chalk, the fossil manure most used, borders the whole district. At Studland Point, and from thence by Dorchester, round by Bere and Wimborne, and from the neighbourhood of Lulworth, there appears to be a line of fault, by which the hard lower chalk has been brought up through the the upper chalk, which has been denuded, the hard chalk having been brought into contact with the eocene tertiaries which abut against it. This hard chalk, though it falls with the frost, is too hard to be used on the light soils, except in the burnt state as lime.

On the stiff clays it would probably be more beneficial, by imparting friability to them, than the soft chalk. Lime is little used as manure. Where used on the newly-reclaimed heath-land, great benefit is found to result from it. A portion of Rempstone Heath, on the Lower Bagshots, consisting of a light, moory soil on a base of clay, has been lately reclaimed by Mr. Calcraft. The process of improvement consisted in draining, spreading the clay from the drains on the surface, and liming. Thus treated, it produces good crops of turnips and roots; and

* This passage has been written six years. For further information on the application of those indentations, which are the transverse sections of subterranean furrows, to draining, see Journal of the Royal Agricultural Society, vol. xiv. p. 96, on the Keythorpe system of draining.

when it shall have been longer under cultivation, there can be no doubt that it will bear wheat.

The soft chalk of Bere and Wool is described as producing very different results on the soils of the lower and middle eocenes. On the former (that is, on the London and plastic beds), and on the red land (that is, the loams of the warp-drift before mentioned), it is used with great advantage at the rate of from 20 to 30 tons to the acre. The farmers on those soils say they cannot grow good corn without it. But on the heath-land —that is, the sands of the middle eocenes, or Bagshot series—it is alleged that it does injury, unless used in very small quantities, "spread like gold-dust"—which, translated into more precise language, means, not more than 6 tons to the acre. The effect of larger dressings in preventing the anbury in turnips is admitted; but it is alleged that, after such dressings, the corn turns yellow and spindly, and does not come into ear, and that these consequences endure for years. This fact is too generally asserted not to have some foundation. Its cause, whether chemical or mechanical, whether inherent in the chalk or in the soil, or arising from a stinted application of organic manures, is an interesting subject for chemical investigation, on which analysis of the soil, of the chalk, and of the plant thus affected, might perhaps throw some light.

In working the china clay of the Lower Bagshots, vast quantities of clay are thrown back into the pits as refuse, either because of the presence of a small portion of sand, or because they contain metallic salts and oxides, which prevent the clay from burning of a pure white colour. To say nothing of the uses to which this refuse clay might be applied, in the manufacture of bricks, tiles, and draining-pipes, it is well worthy of a trial as a dressing for the light soils which abound in the neighbourhood.

Mr. Pike, who works one of the pits near Corfe Castle, informed me that some specimens which he sent to a manufacturing chemist were found by analysis to contain a considerable quantity of potash.*

The water which has filtered through the spoil-banks of these clay-pits is highly charged with sulphates, and, from the presence of potash, was formerly used for the manufacture of alum.

* Colonel Waugh has kindly permitted me to publish the accompanying analysis, by Professor Way, of some of the clay of Branksea Island, in Poole harbour, from the Lower Bagshot strata (June, 1854):—

	White Clay.	Black Clay.
Silica	65·49	72·23
Alumina	21·28	23·25
Oxides of iron	1·26	2·54
Alkalies and alkaline earths	7·25	1·78
Sulphate of lime	4·72	0·00

The presence of iron, however, spoils it for that purpose. By mixture of these clays with lime or chalk, the salts of iron would be decomposed, with production of sulphate of lime.

Here, then, we have several of the constituents of plants, in which the neighbouring siliceous sands and gravels are generally deficient.

The improvement of Mr. Calcraft's heathland before mentioned was effected by means of this clay and liming, in addition to draining. I saw some of the white clay spread on reclaimed heathland near Lytchet, and was informed that it was found beneficial. I saw spread on a field between Christchurch and Bournemouth some of the dark sandy clay, which is frequently associated with the white clay, and was informed by a ploughman, who was at work in the field, that the benefit was visible to an inch on the subsequent crops. In a brick-field between Poole and Bournemouth I inquired if the same dark sandy clay, dug there for bricks, was ever used for the land, and was informed that it did no good, but that the white clay was sometimes applied to garden-ground, and with evident advantage.

On the unreclaimed heath near the clay-pits I also observed a much better vegetation where the rain-water had washed some particles of clay from the spoil-banks over the turf.

Supported by these facts, and by my knowledge of the composition of these clays, and of the deficiencies of the soils of the neighbourhood, I did not hesitate to recommend several farmers and landowners to make experiments with them, both alone, and mixed with chalk or lime.

I also heard of instances in which the Barton clay of the Middle Bagshots had been tried as a dressing for the neighbouring light soils, but the reports of its effects were by no means favourable. The marls of the freshwater series were considered preferable, even brought from a greater distance. The clay, however, was used alone; if it had been mixed with chalk or lime the results would probably have been different. The clay and marl which have wrought such a change in the poor soils of Norfolk, raising them from an annual value of less than 3*s.* an acre to more than 20*s.*, consist either of simple chalk, or a natural mixture, in varying proportions, of clay and fragmentary chalk.

Some of the agriculturists of Hampshire and Dorsetshire, to whom I communicated these views, expressed an intention of trying the experiments which I recommended; but in the localities where the clays of the Lower Bagshots are most abundant, and most easily obtainable, great doubts were in general entertained respecting their value for the improvement of the soil; and a preference was expressed for the "fat" marls of the New Forest, with regrets that they were not accessible. That they

might be rendered accessible I shall hereafter endeavour to show.

In the vicinity of the Forest these marls do not appear to be so highly appreciated as at a distance, though they have been used to a considerable extent. I heard various contradictory statements as to the benefits derived from them. In some cases they were said to be highly beneficial, in others to do no good, and in some to be positively injurious. Some portion of this discrepancy may be referred to difference of soil; but it is important that we should not rest satisfied with this general explanation, but should endeavour to discover in what that difference consists.

The largest dressing of these freshwater marls which I ever saw in the course of application was upon a good and rather strong loam near Milton, on which I should have expected chalk to be more beneficial; while on some coarse sands and gravels near Christchurch, the Forest marl had been tried, I was told, and was found inferior to chalk. The objection alleged against the marl was, that on coarse sands it does not incorporate with the soil, but collects in lumps. It was on similar neighbouring land that I met with the successful application of the dark sandy clay of the Lower Bagshots.

In a brick-field at Pitt's Deep, a little east of Lymington, large quantities of a white marl, composed chiefly of finely comminuted shells, are thrown away as refuse, because it blows the bricks in burning. I suggested its use upon the land, and was told that it had been tried and found injurious, making the wheat yellow, and preventing its coming into ear. The soils of the immediate neighbourhood were strong and wet, consisting of a mixture of flint-gravel with clay of the marl series, and were probably by no means deficient in calcareous matter.

In other cases of failure in the use of these marls, I should infer, from the too prevalent neglect of draining, and the general inferiority of the cultivation (though there are numerous exceptions), that the want of success might be traced to the mode in which they were used, rather than to anything inherent in the marls or the soils themselves. They might have been applied, for instance, to undrained land, or used as substitutes for organic manures, instead of as auxiliaries to them. They might have been applied in too large or too small quantities.

We must not, however, wholly lose sight of the probability of difference in the composition of different beds of marl. The marl series consists of a number of alternating strata, which it is very evident to the eye differ as to the proportions of argillaceous, calcareous, and siliceous matter which they contain, and

an accurate knowledge of the constituents of each is very desirable. In practice, two kinds of these marls are recognised in the neighbourhood of the Forest—"shell-marl" and "cherry-marl." The former consists of clay, rendered calcareous by the presence of shells, whole or only slightly broken. In the cherry-marl the argillaceous and calcareous matters are more intimately blended, and the latter consists of shells very finely comminuted. Its local name originated in some red streaks of oxide of iron, which are often present in it.

Much difference of opinion exists as to the relative merits of these two varieties as a manure. The prevalent feeling appears to be, that the cherry-marl lasts the longest, but that the shell-marl produces the earliest effects. From the bones of mammals and reptiles which have been found in some of the beds, I thought it probable that some of them might contain phosphates, and others not. Under this impression I submitted some of the specimens of the favourite cherry-marl to the examination of Dr. Playfair; but he found nothing to justify an opinion that the difference is traceable to that cause. He found only argillaceous and calcareous matter. This discordance of opinion on the subject of claying and marling is not confined to this district, where the use of these mineral manures is of very limited extent; it is equally prevalent in Norfolk, where it has been long established and extensively adopted. On clay-loams derived from the boulder clay, that clay, being composed of the wreck of the argillaceous beds of the oolitic and other formations mixed with fragmentary chalk, is spread at the rate of 70 or 80 loads to the acre nearly every 30 years; and is considered to "freshen the ground," though the cultivators of such soils are shallow ploughers, and dread nothing so much as bringing up an inch of the boulder clay by a deeper furrow than usual. On the other hand, on the very lightest of the sandy loams of another part of Norfolk, I have seen a ferruginous sand spread as a dressing for the young clovers, and was informed that it had been found beneficial.

The clays and marls of Norfolk consist, as I have stated elsewhere, either of chalk, obtained from the solid rock, or of fragmentary and transported chalk, nearly pure in some cases, in others mixed with blue or yellow clay, the clay prevailing in some varieties, the chalk in others. When Young wrote his Survey of the Agriculture of that county he found so much discordance of opinion among the best farmers, under equal conditions of soil and climate, respecting the quantity to be used, and the crop to which, as well as the season at which, it should be applied, as to render it impossible to deduce anything like a general principle from such conflicting elements.

Nearly the same difference of practice prevails at the present day: some use 100 loads to the acre, others not more than 20. An opinion, however, appears to be gaining ground in favour of light dressings frequently repeated, in preference to heavy dressings at long intervals. Those who favour the former method make an exception in respect to moory sands, when first reclaimed, which, they say, require heavy dressings, and that with a natural mixture of clay and chalk in which the chalk prevails. These are the kind of soils which in Dorsetshire are considered to require the lightest dressings of chalk. Good farmers on light loams in East Norfolk have assured me that they found more than 16 loads of chalk—there called marl —"set their land." Heavy claying, however, with the chalky varieties of boulder-clay containing much chalk, have still their advocates, particularly among the older farmers, subject to the proviso that they must be accompanied by liberal dressings of organic manure. "If you clay heavily," they say, "you must muck heavily, or you will set the land."

Who shall guide us through this maze of contradictions? In general, I have found the opinions of those who rely exclusively on practice, as to the quantities in which mineral manures should be applied, to be guided very much by the facility with which they can be obtained. If they must be brought from a distance, or are covered with a deep overburthen, they are used sparingly: if they are easily procurable, they are laid on heavily.

Chemistry and geology, between them, could solve many existing anomalies in the use of mineral manures; and it may be safely affirmed, that, if they received due encouragement, they would not require half a century for the solution of such questions. What would the expenditure of a few hundreds of pounds on such investigations be, compared with the saving which would be effected by preventing half a county using 100 loads of clay or marl to the acre, if 20 loads is equally, or even more, efficacious?

Conveyance of Mineral Manures by Railway.—I have stated that at a distance from the freshwater marls of the New Forest regret is often expressed that they are not accessible; I now propose to point out how they might be rendered available. The railway system has done good service to agriculture, by the facilities which it has afforded for the transmission of agricultural produce, and by reducing the price of coal to the agricultural population of many inland districts. It has also materially increased the use of light manures, which are applied at the rate of a few hundredweights to the acre, by the facilities which it

affords for their carriage to great distances. The benefits which agriculture may derive from the conveyance by railway of the heavier manures, which are applied at the rate of many tons to the acre, and for the improvement of land by means of the interchange between different districts of those mineral constituents in which the soil of each is deficient, do not appear to have received as yet the attention which they deserve. Chalk and other heavy mineral manures are carted in Norfolk and elsewhere as much as five miles, to be applied at the rate of 20 or 30 tons to the acre. In many cases they are carried that distance from the wharf at which they are landed, burthened with the cost of conveyance thirty and forty miles, on an expensive inland navigation.

The cost of cartage cannot be estimated at less than sixpence per ton per mile. On railways the usual maximum charge for coals, chalk, lime, clay, &c., is one penny per ton per mile. They may therefore at this rate be carried thirty miles on a railway for the cost of carting them five miles.

It is true that on the Dorchester line the rate of carriage authorised to be charged for such goods, and publicly announced as the charge, is twopence per ton per mile; but in practice this is reduced to evenness than a penny, in consideration of a large traffic. The clay, for instance, from the pits in the neighbourhood of Poole, is carried from Poole to Lambeth for five shillings and sixpence the ton. The distance being 117 miles, this is at the rate of less than five-eighths of a penny per ton per mile. The directors of some other railways have stated that with a large traffic one halfpenny per ton per mile would pay them. One shilling and sixpence per ton for 30 miles would be a higher charge than five shillings and sixpence for 117 miles.

The royalty paid at present to the Crown for digging marl in the New Forest is sixpence the cubic yard; and the farmers who use it pay the marl-diggers sixpence the cubic yard for raising it. With these expenses on it, I have seen it carted more than five miles from the pits. The Forest contains so many square miles of the marl series, extending to a depth of at least 40 or 50 feet, that the supply may be regarded as practically inexhaustible, being far greater than any possible demand which can arise from any lands to which it can ever be rendered accessible.

A low royalty, of threepence the yard, with a large consumption, would produce a larger revenue than a higher royalty with the present limited consumption; it is therefore well worthy the consideration of those who manage the Crown property, whether it would not be good policy to reduce the royalty — at least on the shell-marl, which is the most abundant—to threepence the

cubic yard. A cubic yard may be considered equal to 1½ ton. In many places along the line of railway the marl series is so situated with respect to it, rising rapidly 40 feet and more above its level, that it can be worked (if worked on a large scale) at a cost not exceeding fourpence per cubic yard, for raising and filling into railway trucks. I suppose the marl let to a contractor, paying threepence per yard royalty, and making a profit to the same amount on the working of it. The following would then be the cost of dressing an acre of land with marl, carried 30 miles on the railway, and applied at the rate of 20 cubic yards to the acre:—

	£.	*s.*	*d.*
Royalty per cubic yard	0	0	3
Raising and filling into railway waggons	0	0	4
Contingencies and contractor's profit	0	0	5
	0	1	0
Twenty cubic yards = 30 tons, at 1*s.*	1	0	0
Carriage of 30 tons thirty miles, at 1*s.* 6*d.*	2	5	0
	3	5	0

Comparing this with the present cost to the farmers who use the same quantity per acre, at the distance of five miles from the Forest, we have—

	£.	*s.*	*d.*
Royalty	0	0	6
Digging.	0	0	6
	0	1	0
Twenty cubic yards, at 1*s.* . . .	1	0	0
Cartage of 30 tons five miles, at 2*s.* 6*d.*	3	15	0
	4	15	0

The first sum, however, of 3*l.* 5*s.*, would only be the cost of marling close to the railway. At a distance of five miles from it we must add 3*l.* 15*s.* for cartage, bringing the total cost up to 7*l.* At that cost the marls of the New Forest would be accessible to a tract of country, including the Forest itself, should it ever be brought under cultivation, containing 300 square miles, or 192,000 acres, on the west, to say nothing of lands which might derive benefit from them for an equal distance on the east. An acre of marl, ten yards deep, would produce 605*l.*, or 60*l.* 10*s.* for every yard of depth, at a royalty of three-pence the yard, and would dress 2420 acres, at the rate of 20 cubic yards to the acre. Eighty acres would more than

dress the above 192,000 acres, supposing them all to require it. There are in the Forest many square miles of these marls, that is, of clays more or less calcareous, south of the railway, rising to such an elevation that ten yards in depth of marl might be removed without reducing the surface below the level of the drainage, and without injuring the land either for cultivation or for planting—the surface-soil being replaced on the area dug out.

The vast quantities of sea-sand transported into the interior of the county of Cornwall from its sea-coast furnish an example of the magnitude to which a traffic in mineral manures may extend, when once the use of them becomes an established practice. The subject is well worthy the serious consideration of railway companies, particularly those—of which there are many—not over-burthened with traffic of other kinds, as well as of land-owners having poor lands lying contiguous to railways which pass through a country containing mineral manures. In 1811 it was estimated that Cornwall paid 30,000*l.* a year for the carriage of this sea-sand. It forms the chief article of commerce on the Bude and Launceston Canal. It is also carried abundantly by carts, to supply the adjoining portions of Devonshire and Cornwall. Roads and tramroads have been constructed expressly for its conveyance into the interior. One hundred thousand tons per annum were estimated in 1836 as the produce of Padstow harbour alone, a great portion of which was transported into the interior from Wade Bridge by the Bodmin railway; and the total quantity of this sea-sand, which consists chiefly of finely comminuted shells and corals, spread over the surface of the two counties, for the improvement of the soil, is computed by Sir Henry De la Beche, in his Report on the Geology of Devon and Cornwall, at from four to five times the yield of Padstow harbour.

For the improvement of the poor soils which abound on the *lower* Bagshot series for several miles on each side of the Dorchester railway, there are valuable internal resources, either in the natural marls of the New Forest, or artificial marls, which might be made by mixing the clays of the *lower* Bagshot series with chalk or lime. Which of these marls, the natural or the artificial, would be the most economical, must depend upon local circumstances.

Cultivation of Furze for Cattle-food.—Among the internal resources for the improvement of these sandy and gravelly wastes the furze or gorse which they yield in such profusion must not be overlooked.

Furze is often spoken of as a favourable indication of the quality of the soil on which it grows. I cannot subscribe to this

opinion. My observations lead to the conclusion that it only indicates that the soil and subsoil are dry to a considerable depth. Furze does not dislike a good deep soil, if dry, but flourishes with equal luxuriance on the poorest sands or gravels, provided they are free from stagnating water. On cold clayey wastes the long-spined and free-growing gorse is replaced by the stunted gorse with curved spines, which some botanists regard as a distinct species, and others only as a variety.

The sandy banks and the most thin-soiled summits of the gravel-covered tabular hills of the Upper and Lower Bagshots naturally produce the better description of gorse in abundance, and would pay well under its cultivation for cattle-food. It is only necessary to refer to the pages of this Journal for testimony to its value thus applied. We have there well-authenticated instances of land not worth 3*s.* an acre for other purposes paying a rent of 3*l.*, as gorse-grounds, for the rearing of young cattle. I have seen it extensively used as horse-food in Wales; and have known a crop of gorse sell from the same ground, year after year, at the rate of 20*l.* an acre; the purchasers, strange as it may appear, being the small farmers of the neighbourhood, who employed their horses in drawing slates and copper-ore from the quarries and mines. They had plenty of rough land, which would have paid them better as gorse-ground than as poor pasture; but the cultivation of the gorse required some little trouble and outlay, as it is several years before it makes much return; and therefore they contented themselves with the supply which their own farms yielded spontaneously, and, for what they required beyond that, preferred purchasing at the rate above mentioned to growing it themselves. The cultivation of gorse on the worst parts of these wastes would furnish abundant supplies of organic manure for the improvement of the better portions, in conjunction with mineral manures; for the full benefit of the one is not to be obtained on such soils without the other.

To the preceding notice of the agricultural capabilities of this district it may not be amiss to add a brief statement of the economic uses, not strictly agricultural, to which its strata have been applied.

The Upper Bagshot sands yield at Alum Bay very pure and white sand, which is in much request for glass-making. They also yield in the New Forest a sand not quite so good, which is employed in the manufacture of inferior glass. At the junction of these beds with the Barton clay below them there is in part of the Forest a fine loamy sand, used in the iron-foundries.

The Barton clay, and the sandy clays and clayey sands of the Bracklesham beds, have many brick and tile works established on them, and produce red bricks. The Bracklesham beds at Hengestburyhead contain concretionary ironstone, which is collected from the waste of the cliffs, and from the outcrop of the beds on the sea-shore, and shipped to Newport in South Wales, where it is in some request, in consequence of the ductility of the iron which it yields, and its aptitude for promoting the fusion of other ironstone. The supply is small, will soon be exhausted, and the beds would be too much overburthened with sand to be profitably worked, if it were not for the waste of the cliffs. I have nowhere observed so much ironstone in the Bracklesham sands in other parts of the district. It is found in small quantities in the Poole clays and the freshwater marls. Though not sufficiently abundant to be worked profitably, it would generally answer to save it when the beds are worked for other purposes. Ironstone is a frequent accompaniment of the clays which here represent the London clay, but has not yet been worked. Cement-stone is collected from the waste of the Barton cliffs. Beautiful white and sulphur-coloured bricks are made from the calcareous clays of the freshwater marls at Beaulieu, Exbury, and one or two other places. Red bricks are made from the non-calcareous clays of the same series. The beds of white clay, technically called "blue," from its bluish-grey hue when fresh dug, are of great value, large quantities of the fine clays having for a long time been exported to the potteries of Staffordshire and the north of England. A great demand has recently arisen for the inferior kinds of clay from these pits, which do not burn of a white colour, and which are employed in the manufacture of brown or stone ware, now so largely used for sewer-pipes, for vessels for manufacturing chemists, and a variety of other purposes. These inferior clays in the hands of skilful manufacturers yield white bricks equal to the best Suffolk bricks. The mottled clay of the plastic series is also used for brick and tile making, and for a coarse red earthenware. Some of the oldest potteries in England are upon these beds, near Crendle, but have difficulty now in competing, even in their own neighbourhood, with the skill and capital and cheap coal of Staffordshire. The beds of transported chalk-flints form the exclusive road-materials of the greater portion of the district. As the classification and nomenclature of these tertiary strata of the Hampshire district have been considerably modified of late, and in their present state differ considerably from those of any geological maps yet published, except those of the Geological Survey, as, moreover, notices of these changes are only to be

found scattered through various scientific journals, I repeat in a tabular form those which I have adopted, showing the equivalents of each group of strata in the London district :—

		Hampshire District.	London District.
Upper Eocenes	Fluvic marine strata, commonly called Isle of Wight Freshwater series.	Bembridge marls	Wanting.
		Hempstead series	
		St. Helen's or Osborne series ..	
		Headon Hill marls	
Middle Eocenes	Bagshot series.	Headon Hill sands	Upper Bagshots.
		Barton clays .. .. Bracklesham sands	Middle Bagshots.
		Bournemouth sands and clays ..	Lower Bagshots.
Lower Eocenes .	.. ..	Bagnor beds	London clay.
		Basement bed of London clay ..	Woolwich beds.
		Plastic or mottled clay	Reading beds.
		Represented by a thin band with *Ostræa bellavocina*	Thanet sands.
		Chalk.	

The upper Eocenes are wanting in the London district, unless, which appears probable, the upper portion of the Upper Bagshot sands, which are of much greater thickness there than in Hampshire, are a marine representative of some of the Headon Hill marls, which become more sandy in their range north of the Isle of Wight. Outliers of the Lower Bagshots have long been known to exist on Highgate Hill, and have recently been discovered by Mr. Prestwich in the Isle of Sheppey and in Essex. Their presence attests the former extent of these strata and the amount of denudation to which they have been subject.

IX.—*General Remarks upon Continental Farming.* By PETER LOVE, late of Manor Farm, Naseby, Northamptonshire.

HVAING agreed with General Haynau to visit and inspect his estate at Szathmar in Hungary, I was desirous of learning as much as my rapid tour would permit of the different modes of farming practised upon the various soils I passed through, and took such notes as would enable me to profit as much as possible by my transitory visit, or rather flight, through those important countries. I should not have presumed to ask for these remarks a place in the Journal were it not that I know an opinion prevails generally that we as farmers are far superior to other nations; and as I started under that impression, I feel it my duty to give a clear and faithful record of what I saw to admire, as well as what I saw to regret, in foreign agriculture.

I left Ostend by railway for Cologne on the 19th of May, 1853, note-book in hand, and hope that my readers will make allowance for any inaccuracies that may exist in my estimates of quantities, as the rapid flight of the steam-engine gave me but a brief time for making such calculations. After leaving Ostend we passed over several miles of warp land, of great capabilities if well drained and enclosed. The water, however, is standing within about eighteen inches of the surface, causing comparative barrenness where fertility ought to prevail. The greater part of this district is in grass, upon which are pastured thin-fleshed cattle, and sheep, if possible, worse in feeding qualities.

The land under tillage is tolerably farmed (if we except the drainage and breed of stock); the crops of beans, peas, and rapeseed are all drilled about a foot apart, as also a considerable part of the rye, wheat, oats, bere, and barley: about a sixth of the ploughed land is clover, which is a fair crop. This is a district which, if properly drained and enclosed, would, with a better breed of cattle and sheep, more than double its produce.

We then passed over some very light sandy land, with marshes along the river, which were pastured by the same ill-bred stock. This district is nearly all enclosed. The cultivation was tolerably good, considering that it was nearly all done by females, who certainly keep the land free from weeds. I was surprised to see so little land sown or destined to be sown with root-crops, such as swedes, carrots, beet-root, &c.; but a great portion of the land then growing peas and rapeseed was to be prepared and sown with late turnips and transplanted beet after those crops were removed. The crops cultivated were peas, rapeseed, clover, flax, beet, turnips, rye, wheat, and barley; there is too much hedge-row timber, but the poverty of the soil keeps the trees from overshading the land to any serious extent; the roads

are all paved. About Bruges the soil improves; and the warp land is drier; the pasture is therefore of better quality, which continues all the way to Tirlemont, where the warp and meadow land decrease, and the light sandy soil gradually changes to a good sandy loam, which is all cultivated in a husbandlike manner, producing fair crops of peas, potatoes, lucerne, clover, flax, rye (the staple crop), wheat, and some barley: the whole is enclosed with hedges, with timber growing therein, to the damage of the crops, but there is no waste land: the roads are good; there are occasional forests, which appear to be well managed.

From Tirlemont to Cologne I travelled by night, was therefore but imperfectly able to see the country; however, as far as observable, the cultivation appeared to be good and the country pretty. About Cologne is a beautiful district, well farmed, with no waste land about fence-sides, or corners of fields growing rubbish.

After leaving Cologne on our way to Dusseldorf we passed over a pretty district, of light red sandy soil, with some good-sized farmsteads on it, all in tillage except some water-meadows, which are well managed. This part is well farmed as far as the cleanliness of the crops goes, but the crops were lighter than they ought to be on such soil.

We then passed through some poor hungry soil adjoining a barren heath, where the farming was clean, but the crops very light. This was succeeded by a better district, where the farms were generally large, to many of which were attached large distilleries. Although the facilities appeared good for producing heavy crops, yet they were light.

The whole of these districts are open field, which, along with the severity of the winter, prevents sheep from being brought into use for the development of the powers of this light dry soil. If the whole was enclosed, and cheap shelter sheds built with grated floors for the sheep during the severity of the winter, and green crops grown for summer and winter feeding of sheep on the land whenever the weather would permit, and the house-made sheep-manure drilled with the green crops together with bones and guano, I feel convinced there would be more than double the produce obtained from the soil. The industry displayed in keeping the land clean is indeed great; the farmers here do not allow weeds to enter into competition with their crops; a war of extirpation bids fair to free the land of the nuisance.

The crops grown are rye as the staple crop, wheat and rye mixed, barley, oats, peas, beans, rapeseed, tares, clover, trifolium (*incarnatum*), turnips, beet, potatoes. About one-third seemed to be pulse and green crops, and two-thirds white crops, which were all light.

I observed about twenty-five cubic yards of farmyard dung

being applied per English acre for either beetroot or turnips, after a crop of tares had been cut off for house-feeding cows.

The farming implements were of a simple and apparently rude description, but their ploughs were very efficient and the pulverisation of the land was perfect. The ploughs are short light wooden implements, with two wheels; the form of the turn-furrow is such that it completely pulverises the furrow in the act of turning it over, so that the after operations to complete the cleaning and perfect tillage of the soil are few and simple.

After passing Dusseldorf we went through a district of useful, light, dry soil, in large farms, with good and extensive homesteads and some distilleries: farming similar to that betwixt Cologne and Dusseldorf.

We next passed through a large well-managed forest of oaks, beeches, and lime-trees, and entered a light, poor, sandy district, in small farms, producing rye, wheat, oats, peas, turnips, and clover; the farming is beautifully clean and neat, but all the crops were very light, except the clover, which was in many cases a capital crop. Much of the rye and wheat would not exceed 12 bushels per English acre; there is no grass-land nor waste.

This was followed by a district of rather poor, light soil, wholly in tillage; the farms large, kept beautifully clean, and not a yard of waste land to be seen. The crops, except clover, were all light. There is too great a proportion of corn grown. We then passed through a large forest, pretty well managed, to the town of Duisberg.

The whole of the country between Dusseldorf and Duisberg is open field, and light, dry, sandy soil, except a few patches that would be easily drained. I have no doubt that, if these lands were enclosed, and large flocks of sheep kept upon green crops, the produce of corn would be more than doubled, although half of the land were growing green crops, producing wool and mutton.*

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* Large flocks of sheep presuppose large consumption of mutton; an encouragement to the improvement of the lighter class of soils, which lends one of its most characteristic features to English farming, but exists to the same extent in few, if any, parts of the Continent. The traveller abroad has need to bear this in mind (and the caution does not confine itself to this point, in contrasting the agriculture of other countries with our own), in order that remarks may not take the tone of criticism which, in fact, may present only points of self-congratulation. In the course of a tour through the corn-districts of Silesia and Pomerania, during the autumn of 1850, the writer saw, upon a large farm near the corn-port of Stettin, a field of rye of great extent, divided across the centre by a broad strip of land perfectly bare of crop. The corn dwindled away towards it on both sides, thinner and thinner, till it disappeared altogether. On inquiry, the reason given was that the soil on this part of the field was too light to grow any corn-crop. "But why not try to grow turnips, and tread it into closer texture by feeding off with sheep?" I inquired. "I might do that," was the farmer's answer; "but what am I to do afterwards *with the sheep*? The demand here for meat would not be sufficient to find me a market for them." The answer sounded strangely, but it applies to most of the districts passed through in the earlier part of the journey described in the above Essay. Throughout the country, from the Rhine to the

After leaving Duisberg we came through another district of poor, light, sandy soil, all in tillage except a little meadow by the river-sides: the farms small but cleanly farmed; the whole of the crops except clover wretchedly light, not over ten bushels per English acre of rye and twenty of oats, peas about sixteen bushels. About one-sixth of the land is clover, and another sixth peas, tares, and rapeseed; there is fully two-thirds under white crops, which upon such light soil is too much; one-half would be more productive.

Then we passed over a wretched, poor, wet moor; the soil black sand upon a yellow sand subsoil. This is an excessively wet district, the water in general standing within a few inches of the surface. Wherever the water was more than a foot from the surface the land was cultivated, producing miserable crops of rye, potatoes, oats, peas, and clover.

A little further on the soil was wet clay, nearly all in poor pasture, upon which were grazing cattle and sheep of as unimproved a description as the land they pastured on, many parts of which were being taken into cultivation, without the first elements of reclamation, *drainage* and enclosure. Wherever the water is kept off the surface by open furrows, the crops of wheat, beans, and clover looked tolerably healthy.

Both of these districts, especially the latter, would pay well for thorough drainage and enclosure; the drainage would be simple, as there is abundance of fall, the main watercourse only requiring to be opened up to the river, which I fear is prevented either by some old feudal right or the want of capital and the knowledge of drainage. It is grievous to see so much industry expended upon such a bad foundation.

Enclosures now became frequent, with hedge-row timber fences of a rude description; many patches of forest were seen and small farms, showing great poverty, which is not the birthright of such industry.

We next entered a forest of fine oak on the same wet clay-loam soil; then a district, same soil, one-half forest, one-fourth pasture, and one-fourth tillage, producing wheat, rye, oats, beans, tares, rapeseed, barley, and clover; a fair proportion of fallow. On these wet pastures the herbage, though scanty, is sweet.

Drainage is all that is required to make these districts treble their produce, but, as far as I have seen, it appears to be totally unknown on the Continent.

Vistula, the regular and effective demand for animal food, familiar with us, would soon work a revolution in the agricultural system; and the vast tracts of land growing nothing but rye, with only a patch of wheat here and there, might be to a considerable extent applied to wheat-growing, were it aided by the essential preliminary of a ready home-market for meat produce.—C. W. H.

After Cameno station we saw some good pastures and meadows adjoining the river; the upland is still wet clay-loam, about one-third poor pasture, one-eighth oak forest, and the remainder in tillage. All this district is enclosed. The cattle and sheep are of most inferior description. The forests and roads are well managed and the cultivation rather good. Near Rhoda station I observed limestone, which would be invaluable for the whole of those wet districts after they are drained, and the march of intellect will soon cause it to be performed, as the best means of increasing the health and wealth of the country.

The crops grown in these wet districts of clay-loam are wheat, barley, rye, oats, beans, peas, tares, clover, and a fair portion of fallow, which in many cases is sown with some root crop. The farming is very good as respects cleanliness, neatness, working of the soil, and making manure by growing green crops for cows in the house; but all these excellent points in good farming avail not without drainage to produce that uniformity of excellency in the crops which ought to be the result of such wonderful industry as is displayed by the small farmers of those lands.

From Rhoda we went over a wretchedly poor district of black sand soil upon yellow sand subsoil, very wet; one-third is fir and birch forest, one-third barren, and a third cultivated, producing rye, oats, beans, clover, and fallow in part for roots; all the crops except the clover were dreadfully light, not more than from six to ten bushels per English acre. The industry employed here to produce such crops is quite beyond my understanding; for it appears impossible that it can give an adequate return to feed and clothe the occupiers: were drainage carried out, these people would make this comparative desert a little paradise. We here passed along a deep cutting through the hill (the rocks were the mountain limestone overlaying the old red sandstone; the dip is nearly north), and entered a beautiful hilly district, the hills running east and west; soil light dry sand in general; all cultivated except the mountain slopes and tops, which are forest, and comprise about a tenth of the district; farming good, not a weed to be seen.

After leaving Bielefield we passed through some similarcountry, until we got to another deep pass in the mountain, the rock mountain limestone overlaying the old red-sandstone and dipping south; this was followed by a district of poor light sand, which continued until we reached Porta. The whole of this district is beautifully farmed, neither waste land nor weed to be seen; crops vary with the quality of the soil; rye is the staple; wheat, which increases as the soil improves; barley, oats, peas, beans, clover; and fallow for beets and turnips.

At Porta we passed through the mountain, along the river

Weser side, winding our way through the pass worn by the mighty waters through the mountain-chain; the rock, which is mountain limestone overlaying the Silurian, is tilted up almost vertically, dipping south-west. Leaving this mountain, which is but a narrow ridge, behind us, we entered a beautiful district of good light loamy soil, all under cultivation, except the mountain forests, and a succession of meadows that are greatly damaged by the too frequent and lengthened flooding of the river.

This district is enclosed, and sheep extensively kept folding upon green crops, also grazing the meadows, where they are followed by the shepherd, who makes them all eat abreast, clearing the ground as they advance; thus they are not allowed to trample their food into the ground. The breed of sheep, as far as I could judge, are Merinos. The crops are good, and the land as clean as a garden. After passing Minden the soil improves to a good sandy loam, producing good crops of wheat, barley, oats, a little rye, beans, tares, clover, with about a sixth fallow for beet and turnips. The country is here enclosed, and the farming exceedingly good.

Next came a flat of strong clay, surrounded by hills, which are light land; about one-third of this district is forest and pasture; the pasture is generally enclosed, and the cultivated land open field. The farming is not good on this land; indeed the want of enclosure and drainage renders it impossible to farm it to advantage. The crops grown are wheat, wheat and rye mixed, oats, beans, rapeseed, clover, and about one-eighth fallow. The only thing required to make this district one of great fertility is enclosure and thorough drainage, after which it would be extraordinary wheat and bean land. The pastures are grazed by rather a useful sort of cattle and sheep, which, if properly selected for breeding, would soon become good stock.

From Wunstrof we crossed a district of poor light soil, about one-third of which is forest, above a third poor pasture, and the rest cultivated, producing rye, oats, peas, rapeseed, clover, fallow, and a few potatoes; the farming is bad, though the people appear industrious and anxious to get on, but they are sunk too deep in the mire of poverty to raise themselves. I stopped at Hanover for the night, and next morning we entered a district of black peaty silicious soil, upon either chalk or soft white limestone subsoil, standing full of water to the surface. In general, about one-sixth is forest, two-thirds wretched pasture, the rest tillage, producing rye, oats, barley, beans, peas, clover, and a small quantity of fallow: the farming very inferior, and the farmers poor as the crops they grow. Wherever the water is drained off two feet below the surface, the crops are good, thus showing what would be the result of deep and effectual draining.

This would be an easy matter, as the subsoil is very porous, and the drains would be effectual placed forty or fifty yards apart; after which improvement this would be the most fertile district of fifty miles extent in the country, and an honour as well as a mine of wealth to the owners. The soil gradually changed to a good loam, and, though not quite so wet, would be much improved by drainage. This district is as well farmed as is possible without enclosure and drainage, producing tolerably good crops of wheat, oats, peas, beans, clover, and fallow for green crops.

It is distressing to see land of such capabilities enjoying an excellent climate, and occupied by a race of first-rate farmers, and yet remaining unimproved for want of a moderate outlay of capital. After passing Brunswick there is a district of beautiful undulating upland, soil dry light loam of great fertility; there is a considerable tract of low fenny marsh by the river-side, which, if drained, would be extraordinary land either as grass or tillage, could the river be deepened so as to keep the water three or four feet below the surface: in fact, as it is, wherever the water lies two feet below the surface, it is in tillage producing excellent crops.

This district is not enclosed, but the farming first rate. Large flocks of sheep are kept and folded upon green crops, also large herds of cattle grazing the marshes, which extend to about a tenth of the district. The crops grown are wheat, barley, a few oats, tares, peas, beans, clover, and sugar-beet: the management of this crop is truly excellent. We saw gangs of hoers from five to sixty-four in number; I was informed that three represented a hundred acres English, therefore the farms are from one hundred and fifty acres to upwards of two thousand. The homesteads are large and substantial, and, with their steam-engines and tall chimneys, are an imposing sight to the lovers of agricultural improvement.

I think this (notwithstanding the want of enclosure and drainage of the marshes) is perhaps the best-farmed district I have seen. The horses used are nearly thorough-bred, and their rapid movements, combined with the activity of their labourers, form a strong contrast with the sleepy smockfrocks of our southern counties. Nearly the whole of the crops are drilled and horse-hoed in this district, and a weed or a square yard of waste land is a rare thing to meet with.

Farmers here are wealthy, as such men ought to be. There appears to be considerable improvement going on in the breed of cattle and sheep, from care and attention being paid to the selection of breeding animals, and rearing and keeping them upon more nutritious food. The same description of land and farming continues for many miles after passing Magdeburg; then the soil gradually changes from light loam to very light poor sand of

reddish colour upon white sand subsoil. In this district the farming is clean, and great economy, industry, and care are bestowed on every department. Nature has done but little; however the people make the most of it. A portion of all the green crops is folded off by sheep, and the rest consumed by the cows in the house, making manure. There are scarcely any horses used in this district; the whole of the work is done by the dairy cows, a pair of which walk along with comparative ease drawing excellent little ploughs. They appear to work the cows in relays of about three hours each pair per day, drawing the manure out, the weeds home, soiling tare or clover as they go and return from plough. I was told that the exercise was conducive to the secretion of milk of better quality. I was struck with the mode of yoking cattle here, viz. a board about six inches wide and two and a half feet long, tapering to both ends, where there are hooks similar to those used on the ends of our swingle-trees: this board has padding under it, and is hung to the horns by two straps, which suspend it across the forehead, just below the horns; the traces are attached to the hook at each end of the pushing-board. Thus the animal has the line of pressure caused by the draught or tractions passing straight along the back-bone, pressing its joints more closely together. After looking minutely into the working of this system, and observing the ease with which the cattle drew their loads, chewing their cud as they walked along, I became convinced that it was the proper mode of yoking oxen.

I was surprised at the ease with which two small cows drew the plough, working at least six inches deep; but the soil is very light and free. Their ploughs are, probably, the models from which the Americans took theirs, being very short and light; the shortness of the mould-board makes them easy in draught, while it completely breaks the furrow-slice to pieces in the act of turning it, so that the implements required to pulverise and prepare the land for turnips, after tares and other soiling green crops, are few and simple. There is no bare fallow for turnips, &c., in this district: two green crops in the season is the rule, also turnips after peas.

This district extends the whole way to Dresden, from whence I travelled by night to Prague, and as far as I could see the same description of soil and farming continued on the upland for some distance. After passing along the side of the Elbe, through the mountain up into Bohemia, the soil became various and hilly, the farming gradually getting worse until we reached Prague. After leaving that town we passed a hilly district, consisting of dry and stony soil, and reduced to great poverty by the system of over-cropping practised by the farmers who occupy this country. They keep the crops tolerably clean, but too much land is sown with wheat, rye, and oats, and too little peas, tares, turnips, and clover grown. The farms are small and the farmers very poor.

About one-eighth is forest, and there are some water-meadows along the river-side; about one-third consists of barren hills, and the rest is tillage, except a little pasture adjoining the forests. This country, if properly enclosed, with cattle soiled upon half the green crops in houses, and sheep eating off the other half on the land in folds, would soon treble its present production. But I fear that the people are too poor to be able to help themselves, or advance without aid: indeed it is evident that, as the land becomes reduced in productive power by the too frequent sowing grain crops, so are they driven to sow a greater width, until the land is reduced to the lowest degree of poverty, returning little more than double the seed sown. Such being the case, it behoves the state to look to the interest of a people who are thus industriously struggling with difficulties.

We now followed one of the main tributaries of the Elbe to where its source issues from the same spot where the river March or Maravia has its source. This latter runs into the Danube, and the railway follows its course through rocky passes, woody dells, little fertile plains encircled by rocky cliffs and steep hill-sides, adorned with gigantic trees and shaggy woods. Along this beautiful way we swiftly rolled, gazing with delight upon the romantic rocky cliffs and the limpid stream, with its tortuous windings.

Water-meadows and flax-mills were seen along the whole of this route, and the processes of steeping and preparing flax were in active operation.

On issuing out of this tortuous way the effect is truly beautiful, from the prospect afforded of the extensive plain on which stands the busy town of Brunn (the Leeds of Austria), where all is activity, both in town and country. The land is magnificent, a fine alluvial loam, generally dry, except where the river-water is pent back for want of proper fall. From this cause there is a large tract of marsh or fen about Brunn, which, if drained, would either become rich pasture or first-rate tillage. These extensive marshes are grazed by large flocks of sheep, herds of swine, and cattle.

The herds are attended by shepherds before and behind them, who keep the stock far too close together, and move so fast, that they damage more grass with their feet than they eat.

The cattle are generally large, of dun colour; and, if well managed in the selection of breeding-animals, would soon become a first-rate breed.

The sheep are something of the Merino breed, carrying but little mutton. The pigs I do not like; they have too much head, legs, and hair about them.

After leaving Brunn, the upland is first-rate light loam, dry, and in part enclosed; the farming is pretty fair; but as we got

on towards Vienna, there were evidences of a paralysed state, through poverty and want of confidence. This is a district farmed by men who own and occupy from thirty acres English to twenty thousand, the homesteads of which are on a most gigantic scale, substantial, well arranged, and built of first-rate materials.

The horses used here are nearly thorough-bred, strong, active little animals, doing all the light active work; the whole of the heavy haulage is done by oxen of large size, very active and strong; they are always worked with reins, either double or three abreast, when in the plough, or other implement, in such style as would put the long-team farmers of England to the blush. A pair of oxen is tasked to do six roods English per day. The plough and waggon are the same throughout the whole of the countries I passed through; and although they are rude-looking implements, it would not be an easy task to improve either of them without expending more capital than would return fair interest: indeed, if thorough pulverisation of the soil is the object of cultivation, the continental plough is superior to the British.

Within some miles of Brunn I saw a field of land preparing for sugar-beet and turnips, the extent of which I was informed was upwards of 3000 acres. The management of this field was truly splendid; about two-thirds was thinned, and part of it just up, while the remainder was being sown; there were upwards of 100 teams at work. Besides those teams that were hauling the manure, there were four drills at work, which were kept regularly going, following each other: thus they were covering about 33 feet as they passed along. The field was upwards of three miles long, and they were drilling from end to end. The land was perfectly level, so that the whole was to me an imposing sight.

I was informed that the owner of this farm was a gentleman from Saxony, a native of that magnificently farmed district where sugar-beet is grown and manufactured into sugar so extensively. It is evident that this gentleman will give the impulse this splendid country requires.

As we approached Vienna the land became lighter, and the farming still more neglected; indeed we travelled some miles through fine land that had been completely laid waste during the revolution.

On the 25th of May I started on my way to General Haynau's estate at Szathmar in Hungary.

From Vienna to Presburg, by railway, we passed through a district of capital light dry soil, with occasional spots of poor light sand, and here and there some low wet soil. This district is nearly all cultivated, but the farming is generally bad, a system of overcropping being the rule. It is all open field; weeds are the universal companions of every crop; even the vineyards are

not free from them. There is every indication that farming here has gone sadly back since the disturbances.

This beautiful plain, through which the Danube flows, is sheltered on the north by the mountains that separate Moravia from Austria, on the slopes of which vines are grown. This is universally the case upon all slopes facing the southern sun.

The crops produced are wheat, barley, a few oats, maize, peas, potatoes, beet, turnips, lucerne, and clover; lucerne is indigenous throughout the whole of this country. The crops were all light, as might be expected, for more than two-thirds of the land is under white grain; and the maize, peas, and green crops are not well cleaned nor tilled.

After passing Presburg we travelled over about eighty miles of fine sandy loam soil, from one to two feet in depth, with a few tracts of poor light sand, and wet poor pastures. These pastures are grazed by large flocks of sheep, herds of cattle, horses, and swine. The quantity of stock is too great, keeping the grass so short that there is but a bare existence for the animals grazed.

The cattle are large dun Hungarians, or small brown and black mountain stock; the sheep are a mongrel-bred Merino, with no disposition to fatten; the swine a sorry breed indeed. If these pastures were drained, they would become useful, and in many parts good feeding-land.

Nearly the whole of the dry land is in tillage, but the farming bad: there appears nothing like system in the country, unless it be growing grain as long as the land will bear it. If this and the former district were enclosed, half the land devoted to green crops to be consumed by cattle and sheep, and the land well cultivated, there is no doubt that the produce would be doubled, or even trebled. As we approached Wartzen station the country became more and more hilly, until we reached the chain of hills or mountains that runs south from the Carpathian mountains. Through this chain the rapid and majestic Danube has worn a beautiful valley. The scenery is truly beautiful, the hills rising higher and higher, until they reach the mountain-chain. This is a mountainous district, with forest-clad slopes and mountains on either side, and vineyards cultivated up the slopes wherever they face the mid-day sun. We passed along this magnificent valley, which varies in width from the mere tract which this rapid river has worn through the rocky mountain to many miles. The soil is a light loam of great capabilities. As we recede from the river the land is slightly hilly, the soil light and earthy, reduced to poverty by the system of growing white crops too frequently. Farming is slovenly and bad. The crops produced are wheat, rye, barley, few oats, maize, peas, potatoes, very few turnips, clover, and lucerne. All this district is open field, and

the crops light; about five-sixths of the land is in tillage, and one-sixth in pasture.

At Köbölkut we entered a more level district of deep light loamy soil: this part of the valley is several miles wide, with the forest-clad mountains in the distance, and vine-growing slopes on the southern sides of every hill; but the valley gradually gets narrow, and the mountain sides approach with their beautiful scenery. There is about one-third of this district cultivated, producing rye and wheat mixed, rye, barley, maize, peas, potatoes, and a little clover; farming bad and crops light, not more than 16 to 25 bushels per acre English. This land, when first ploughed up, produces from 40 to 50 bushels of wheat per acre English; such being the case, if the land were afterwards well farmed, 40 bushels would be an average crop.

The pastures are grazed by large Hungarian cattle, which are a good sort of stock; the sheep bad; and the horses, of which there are large hordes, small, useless-looking, ugly creatures, too light for draught, and ugly for either riding or driving, yet hardy and durable, and might by good management in breeding soon be made a good breed of roadsters.

Before reaching Pesth we passed through a poor sandy district nearly all in grass, rather undulating; the crops, wher cultivated, light, and farming anything but good. The whole of the distance from Vienna to Pesth is capable of producing at least treble the quantity of beef, mutton, wool, and grain if well farmed; but the people of this beautiful country are broken in spirit and sunk in apathy; and so long as uncertainty prevails, industry cannot become the propelling power to wealth.

I stopped the night at Pesth, at the Europa Hotel, where everything was cheap and excellent in quality. The new bridge over the Danube is a magnificent piece of architecture, which had a narrow escape from destruction during the revolution.

On our way to Szolnok, by railway, we passed over a district of about 30 miles of light loamy soil with slightly undulating surface: indeed it is so level that there is not a single railway bridge from Pesth to Szolnok, about 60 miles. For the first 30 miles about one-third of the land is cultivated, producing wheat, rye, maize, peas, and potatoes; the crops were various, the farming very bad: the formation here is drift of the old red sandstone and mountain limestone, forming a splendid soil for general tillage. The next 30 miles form part of a vast plain of light black vegetable earth upon an alluvial sandy subsoil; the depth of soil varying from 1 to 4 feet. A great portion of this district is but a few inches above the level of the rivers and streams: the highest and driest parts are cultivated, producing wheat, rye, maize, tobacco, and potatoes. The farming is bad, but the crops are generally good; indeed, if this district was

properly drained and well farmed the produce from it would be enormous; at present the bulk of it is grazed by large herds of cattle, sheep, pigs, and horses, which are attended by herdsmen, who keep them progressing regularly over these immense marshes.

What a glorious sight it would be to see all this plain drained and cultivated as it ought to be! thus insuring an abundant reward to the industry and perseverance required to bring about such reclamation and improvement, causing health and wealth to prevail where now nothing but sickness, decay, and poverty exists.

The Hungarian peasantry are a fine, strong, active, well-made race of men; they have just been emancipated from serfdom by the present Emperor of Austria; and being now in the transition state, will no doubt soon raise themselves in the moral scale as far as the circumstances of their country will permit: they are in a shocking state of poverty, working barefooted and legged, with only coarse canvas shirts and trousers (if they are worthy of the name); they are just a wide petticoat cut up the middle, and each side sewed up to form legs; the waistband is the same as that of a petticoat; their coats are sheepskins, with the woolly side out, dyed black. It is evident that these people feel acutely the degraded position they have risen from.

From Szolnok I started for Tokay by steamboat up the river Tessis; the distance as the bird flies is under 150 miles English, but by this circuitous, muddy river it is above 400 miles. Both its banks are but little above the water, and for 10 miles on the west side and nearly 50 on the east side more than two-thirds of the land are laid under water for several months after the thawing of the snow on the Carpathians and the breaking up of the ice in the lowland morasses and streams. When these floods subside a pestilential vapour rises up, spreading fever and ague among the towns and villages throughout these low lands, thus weakening and thinning the population of the country.

The steamboat was English built, the engine by Penn and Co. of Greenwich, and the technical terms used were all in the English language: we were two days and two nights in getting up to Tokay. Many of the towns we nearly sailed round, at a distance of some miles from them. The land frequently in these sort of peninsulas, or links, is the highest above flood watermark. Not much of this country is cultivated except about the towns and villages, which are few and far between. In the low country the system of farming is very rude indeed, but the land is rich and fertile where it is sufficiently above watermark, and the crops consequently good, and in many cases abundant. The great wealth of this country consists in large herds of cattle, horses, pigs, and flocks of sheep. Where the land is high and dry the cattle are grazed in herds of the same age and sex: if these cattle were

well selected for a few generations, there is no doubt that they would be one of the best breeds in the world: great numbers of them are excellent handlers—they are deep in the rib, wide in the back, deep and broad in the thighs, deep but rather narrow in the breast; their head and horns are in many cases beautiful; the worst fault they have is flatness in the rib: they are the finest working oxen in the world; always yoked so as to push with the forehead, so that the work in no way disfigures them as our system of yokes and collars does.

The swine are fattened in great numbers, after the subsiding of the floods, upon fish and frogs that swarm the shallow pools in these marshes, but their flesh is not fit for food, therefore the whole carcase is melted down and the fat mixed with beef and mutton suet to make tallow; the dried flesh is given to other young pigs that are growing, thus it gets double refined; large quantities of pigs are also fattened in the oak forests upon acorns. Hungary supplies the greater part of Austria with beef, mutton, pork, and horses. The herbage on the land which is not liable to flood is of the finest description; in fact I have no doubt that this whole plain, exceeding 21 millions of acres in extent, could not be excelled by any land in the world for fertility, if properly drained and cultivated; it might produce more than one and a half million tons of beef, mutton, pork, butter, and wool, which at the low price of 4½*d.* per lb. amounts to 63 millions sterling; wheat at least 24 million quarters, which at 30*s.* per quarter, amounts to 36 millions sterling; of rye, barley, maize, and tobacco, say 31 million pounds sterling, making a total of 130 millions, of which one half may be allowed for exportation annually, enabling these people to consume foreign necessaries and luxuries to the value of 65 millions annually.

There were nothing like hills to be seen, except to the north, all the way: these mountains we were gradually drawing near, until we reached the first hills at Tokay. All the hill-slopes are covered with vineyards, but the cultivation is not good, indeed many of them are much neglected. There is every appearance of Tokay having once been a place of great wealth, though it is now going fast to decay. These hills are the beginning of the Carpathian mountains; but there are about 40 miles of beautiful vine-clad hills and fertile valleys before the main mountains are reached: cultivation is in a most backward state here. Nature has given them vines that make the most delicious wine in the world; what an immense produce would be the result if the vineyards were managed as they are on the banks of the Rhine!

I went to a large fair that is held the first week in June near Tokay, where there were immense droves of cattle, pigs, horses, of all ages, brought for sale; also great quantities of cattle, horse,

and pig's hides, and grain of all sorts, agricultural implements of all the kinds used in this country; everything was selling 25 per cent. higher than formerly, owing to the depreciation of the paper currency now in use throughout the Austrian dominions.

I saw new waggons, that were warranted to carry 50 cwt., sold for the equivalent of 5*l.* sterling; new ploughs, made of wood, with two wheels, from 1*l.* to 1*l.* 10*s.*; those at the latter price were useful implements.

Good store bullocks, 4 years old, that will feed to from 9 cwt. to 10 cwt., sold at from 7*l.* 10*s.* to 12*l.* They were in rather low condition; but were expected to make from 2½*d.* to 3*d.* per lb. when fat.

Barren cows sell for about 1½*d.* per lb. of what they will feed to, and in-calf cows sell for about 2*d.* per lb. of what they would feed to. The best Hungarian cows would feed to about 8 cwt., and sold at the equivalent of 6*l.* to 7*l.* sterling.

Store-pigs were sold for about one-third less than in England, but bacon is as dear as in England.

Farm-horses, a sort of mongrel-breed, of small size, about 15 hands high, bad shapes, but hardy and durable, 4 to 6 years old, sold at from 4*l.* to 6*l.* sterling each.

Land lets at from 10*d.* to 4*s.* 6*d.* per acre of 4800 square yards.

Labourers are paid from 10*d.* to 1*s.* 3*d.* a day, according to ability.

The average crop of wheat is about 24 bushels per Hungarian acre; 50 bushels is a common crop upon newly broken-up land.

Much of the best grass-land will fatten the largest bullock per Hungarian acre in about 100 days.

Thrashers receive 1-11th of the produce for thrashing, and reapers receive 1-11th for reaping, binding, stooking, and storing home all sorts of grain-crops.

The roads generally throughout Hungary are mere tracks made over the driest part of the land, from one town or village to another, therefore travelling overland is a rough uncomfortable task. I was much pleased to find that this people had studied the best principles of mechanics in the construction of their rude waggons and other carriages, and that they also displayed knowledge in their mode of attaching oxen or horses to wheel carriages, so as to enable them to get with the greatest ease through the many sloughs or mud-pools that occur on these roads, or rather tracks. To give one instance: they yoke their horses and oxen with very long traces, so that the team is out of the slough upon the sound ground before the waggon or carriage requires severe pulling to draw it out; they invariably go through these sloughs at a canter, so that, the moment the teams see pools of water or mud in the road, they start and canter through it as fast as the weight of their load will allow them.

It was truly distressing to see the waste of labour that was taking place in making a new highway at Tokay: 2 men and 2 boys were employed making an open drain at the sides, but doing less work than one of the men could have done with a good spade and shovel. The hoe was their only tool, and they were working thus: one man hoed up the alluvial earth, and scraped it into a basket which one of the boys held between the hoer's feet until filled; then he handed it to another man on the bank, who threw it into a waggon, in which a boy was placed to throw out the baskets. Now these men were harder worked than one of them would have been digging up the earth and filling it into the waggon. Spades and shovels appear to be unknown in this part of the world; the hammers also used for breaking the stones are far too heavy. I regretted to see how they wasted the stones in making this road; they were carting them of all sizes just as they came from the quarry, and throwing them down promiscuously among the muddy earth, into which the waggons were cutting almost axle-deep; then they merely levelled the top of the load, and broke any stone that rose above the rest. They then threw more stones on, and partially broke them. Thus are the roads made by the government of a great empire and noble race of men in the nineteenth century. From Tokay to Szathmar we travelled by post-conveyance, namely, a light waggon and three horses; the expense under 8*d.* a mile English. This was a wretched journey over a miserable track-way, no part of which was made with hard materials. Much of it was scarcely passable; in fact, if an hour's rain falls, the road almost becomes impassable. All the way from Tokay up to Neurithaze, upwards of 40 miles, the land is a vast plain of alluvial soil of great natural fertility. About half is in grass, upon which large herds of oxen are fattened. The farming is bad; the growth of tobacco, rapeseed, potatoes, and sunflowers, which return little or nothing to the land in the shape of manure, has much reduced the powers of a naturally rich soil. Many of the crops of potatoes, maize, and tobacco were excellent, though poorly cultivated; the crops of wheat, rye, and oats were generally light, about 2 to 3 quarters per acre of wheat, 4 of rye, and 6 or 7 of oats. Some land that had been better manured was growing heavy crops of wheat, and some newly ploughed-up grass-land had an immense crop of oats and tobacco growing upon it. There are numerous marshes that are lakes in winter; these swarm with wild-fowl and grow reeds of great length and strength.

Neurithaze is a large straggling town, planted all round, and having some beautiful walks and promenades. From Neurithaze to Karolz is about 30 miles of a poor sandy district of an undulating form; the sand is red, and so light that it often drifts by

the wind like snow; in many of the hollows are morasses or reed-ponds, which literally swarm with all sorts of wild water-fowl. About half of this district is cultivated, producing wretched crops of wheat, rye, potatoes, and maize. The pastures graze poor-looking stock, which the grass is not likely to improve much. Large stocks of geese are kept.

Karolz is a clean town, with many good buildings in it. From it to Szathmar is about 50 miles of a strong alluvial loam, of great fertility, above two-thirds of which is under cultivation, producing wheat, oats, maize, sunflowers for making oil, rape-seed for making oil, tobacco, potatoes, and melons, on which large quantities of pigs are fattened annually; tares, clover, and lucerne are grown, and used for soiling the working oxen and horses. This system of cropping is very severe upon the land, so little manure being made and applied to the soil, yet the crops are good. The sunflower grows above 8 feet high, and some of the maize was getting a good height. Large orchards of plum-trees are grown: the fruit is used for the distillation of brandy. There are also considerable quantities of hemp grown, which is another scourging crop. Indeed, the produce of this country, if well farmed, would astonish the agricultural world. Much of it requires drainage.

Szathmar is a well-built, clean town, of considerable importance. Here many of the nobility live, who are a proud race; the people of the town are also inclined to think more of themselves than anybody else does; they are very fond of showy dress.

I found General Haynau's estate was low and wet, without the proper means of drainage, on account of there being no outfall, without cutting through another estate, the owner of which was opposed to draining altogether, because, he said, they suffered oftener from drought than from wet. The General has about 2000 acres in tillage, and intends ploughing up a great deal more, and erecting oil-manufactories, distilleries, and a sugar-manufactory, provided he can get his estates drained. This depends upon a lawsuit now pending, which I hope he may gain, that he may be enabled to make the most of his splendid estates. He breeds and rears immense herds of cattle, and fattens off upwards of 2000 head per annum, besides some hundreds of horses.

It was grievous to see some of the wheat that had been swamped with water and then followed by dry hot weather, which set the land so that the cracks were 3 and 4 inches wide, and above 4 feet deep. The wheat on this land was truly the most mysterious crop I ever saw; the straw was not above a foot long, and the ears were likely to average upwards of fifty

grains each. I believe that there would be at least 28 bushels per English acre. Now, if that land was drained, what would it not have produced? The General grows about 300 acres of meadow per annum on one estate, and 400 on the other. His crops of hay were about 2 tons per English acre. As the General was not at Szathmar, I returned to Vienna to see him.

In returning to Tokay I took a different route, more to the north, through Berocszacz. The whole line of way is beautiful; alluvial clay loam of great fertility, about one-half in tillage and the rest pasture. Lakes are frequent, but they are generally shallow, growing immense crops of reeds, and abounding with wild fowl. Hares are also numerous throughout the whole country. The farming is anything but good, yet the crops are in many cases abundant. Wheat, oats, maize, potatoes, rapeseed, sunflowers, tobacco, hemp, clover, and lucerne, are the crops grown, which, if well, or even moderately managed, would be magnificent.

The Hungarians are excellent horsemen, and use a lasso in the most dexterous style in catching the wild horses from the herd: as soon as they have caught one they immediately mount, without saddle or bridle, and with a short whip guide him at full gallop, until he is so tired that he is glad to walk; then the rider jumps off and on his back, and goes through all sorts of manœuvres, turning him round, first to the right, then to the left. The horse is managed in that manner for two or three days, then a bridle is put on him, and he is properly mouthed. A waggon and six, three and three abreast, driven over the rough tracks from town to town at a rattling pace, is a fine sight—so much tact in the driver and tractability in the horses are required to get safe over the sloughs and swamps that frequently occur in travelling over these unenclosed plains.

After I arrived at Tokay I had to wait two days for the steamboat, so I took some hours' walk among the hilly country to the north of the town, and went to the top of a high hill, by which I was enabled to see a great distance through the valleys on every side. These were more thickly populated than the plains. The land was a first-rate light loam almost to the top of the highest hills; the farming bad, but the crops were productive, even those that appeared small; there were many vineyards which were not well managed, also large plum-orchards: here lucerne grows to a large size—indeed, it is one of the most smothering weeds that infest the land. This would be a glorious sheep and tillage farming district in the hands of good managers. There is a good deal of drainage required among the hills and valleys. A wooden bridge across the Tessis at Tokay, which is now being built, will much facilitate the traffic on the river, as the present floating bridge

(which is of the most rude description) is only opened every morning from sunrise to about ten, to let the rafts of timber and floats of merchandise through; any that arrive after ten o'clock in the morning have to wait until the next day, which is a great hindrance to the navigation.

The Hungarian butchers are rather a rude sample as compared with those of England. I do not know how they kill their cattle, but they do not half bleed them. They dress the meat badly, and their mode of cutting up is disgusting; they use nothing but an axe, with which they chop it up into such sized pieces as their customers require. They are good cooks, and if the meat was nicely killed and dressed by the butcher it could not but add to the goodness of the food, as well as save some of the sauces that they flavour their various dishes with.

I met with great kindness and hospitality from the Hungarians; in fact, they appeared as if watching for opportunities to do me a kindness or service.

I returned to Vienna by the same route as far as Pesth; from whence I went up the Danube in a steamboat, from which I could not see much of the cultivation. There is some beautiful scenery, and the clear water of this river, as compared with the thick muddy stream of the Tessis, was enlivening. All along the slopes facing the south is growing the gladdening vine, whilst the opposite sides are clad with shaggy woods, which also clothe the upper summits on the south, giving life and beauty to the scene. In many parts the rugged rocks rise above the trees in romantic turrets of striking beauty.

After I had seen Baron von Haynau, and settled our business at Vienna, I was introduced to Mr. Haswell, the intelligent and talented manager of the railway-engine and carriage manufactory at Vienna: he is a native of Glasgow, which may be proud of her son. These are the second largest works of the kind on the Continent, and are second to none in arrangement and discipline. Mr. Haswell kindly introduced me to Mr. Smallbones, of Deutsch Kreutz, near Odenburg, in Hungary, consulting agent to Prince Esterhazy, under whom he occupies an extensive farm, which is a model of what can be done by English ingenuity, industry, and perseverance. Mr. Smallbones is highly thought of in Hungary by both rich and poor. By invitation I went down from Vienna to visit his farm in Hungary, which gave me much gratification, convincing me that the views I had taken of the productive powers of the soil of that ill-cultivated country were sound and correct. Mr. Smallbones' farm is upwards of twelve hundred acres English, all in tillage; he has likewise extensive rights of pasturage upon the neighbouring plains. The country all around Odenburg is slightly hilly, with mountains in the

distance. The soil is a naturally fertile light loam, but, through the wretched system of farming practised, its productive powers had been much reduced; however, the example and success of Mr. Smallbones must ultimately do great good. Mr. Smallbones grows about 450 acres of wheat, 150 of barley, 150 of maize, which he cuts green for fattening bullocks and feeding his farming horses and oxen; 150 acres of tares, which are partly eaten in the houses by the fattening cattle and teams, the rest is eaten on the land by sheep, which have a liberal allowance of corn or cake at the same time: this crop is immediately followed by a crop of turnips. He has also 150 acres of mangold-wurtzel, and 150 of clover, with about 50 acres of lucerne. I believe his rotation runs thus: wheat after clover, tares followed by turnips, barley, Indian corn sown thick for soiling cattle, working oxen, and horses, wheat, mangold-wurtzel, wheat, clover.

The soil, like the surrounding country, is naturally good, but when it came into his occupation was in a poverty-stricken state: he set to work, however, with the full determination of showing what could be done in the way of improvement. Mr. Smallbones came over to England and took out a stock of the machinery and implements best adapted for the country and his system of farming: he is now getting his farm into excellent condition; although he has only had it a few years, his crops on all those fields that have been fallowed with roots are excellent, notwithstanding the season has been an unusually dry one, which has greatly reduced the usual bulk of straw, but the ears (on the land in good condition) were beautifully filled, with fully-developed grain: when I was there he was having his clover mown for hay; it was the heaviest and longest crop of clover it has ever been my lot to see; above a yard high, and as thick as it could grow; and to see above a score mowers hard at work on 140 acres of such a crop, was one of the finest agricultural sights that could be witnessed. Mr. Smallbones has arranged his farm in rotations as near 150 acres each as the form of the land will permit; but has adopted the clever plan of making four fields as nearly as possible 75 acres each close to the homestead, and four of the same size at the greatest distance, one of each being cropped together, while in the middle distance the fields are the full size of 150 acres: thus he makes the distance, for the manure and other haulage to be done, the same one year as another, which is of great importance.

The house is a splendid edifice, and the farm-buildings are of the best description, and conveniently built. He had upwards of 100 head of large Hungarian cattle up feeding upon tares; they were to be finished upon Indian corn or maize cut green, which is very fattening food: he had also 30 working oxen, 30 horses,

and a large flock of sheep, which are folded on the same land 48 hours, eating mown tares and cake or corn mixed with a little chaff: directly the sheep are off, the land is ploughed, pulverized, manured and sown with turnips; thus the field is got over as fast as the tares are consumed. Part of the crop was up, the drills showing well, and proving by their straightness that the drill had been guided by a good workman; indeed I saw Garrett's drill and horse-hoe, both, managed by Hungarian ploughmen as well as I have ever seen them in England. They were using the horse-hoe among the mangold-wurtzel the second time before thinning, which operation was also being performed in a most satisfactory way. It was gratifying to see the efficiency and expedition exercised by these poor ill-used people when properly treated.

Mr. Smallbones' farming is first-rate; he drills his roots 16 inches apart and his grain 10 inches, and horsehoes the whole. Well-ordered economy is the rule of his establishment.

He has several German, Austrian, and Hungarian gentlemen's sons learning the art of agriculture with him.

I may state that he finds that the proper way of making oxen work is by pushing their forehead against a padded board, to the ends of which the traces are attached, as is the universal system throughout nearly all the continental nations. The oxen so worked are in no way injured for the butcher; they can also travel faster, chewing their cud at the same time; and can work longer hours without being overtired. He also finds that the plough in general use is much better than ours for moving and pulverising the soil; and that the rude waggons of the country are as economical as our more powerful and highly-finished ones made in England, from their only weighing half the weight of ours. Weight is of paramount importance where the roads are generally mere tracks across the country; also, where produce has to be drawn a great distance to market, the proportion of power consumed in drawing the carriage to and fro is of vast importance, therefore this people adopt as a rule, in which he agrees with them, and so do I, that the *carriage* should never exceed *one-fifth* the *gross weight* of the *load*. These are, I believe, the only implements in which the continental nations excel us.

After I left Mr. Smallbones I observed that the farming was much better near his farm, and that it gradually declined as we got further from him: there was, however, occasionally to be seen amongst the large owners one who was taking example by him, and had imported some of our best implements, such as Hornsby's drills, Garrett's horsehoes, and Crosskill's clodcrushers, and was also draining his land and enclosing it in proper fields for rotation husbandry. This I have little doubt will soon become the rule

in place of the exception as at present; for when we see a people taking up the example thus shown them, and unprejudicedly adopting it as far as their means will permit, it argues well for their advancement, especially when that example is such as will lead them to wealth and prosperity.

Mr. Smallbones is now beginning to breed Hungarian cattle, with the view of improving them to the utmost. He has also been making great improvement in his flock of sheep by careful and judicious selection of his male and female animals; he is of opinion that the best way to get first-rate stock is to improve the *native breeds* by proper selection, treatment, and feeding, in which opinion there is much sound judgment and sense.

X.—*On Feeding Cattle on Turnips raised with different Manures.* By ANDREW TEMPLETON.

IN laying before the Royal English Society the results of the experiments in the following Tables, I have endeavoured to make them as accurate as possible; and as the feeding of cattle, when judiciously performed, is most important to the feeder as well as profitable, it is a subject well worthy of our fullest consideration. Being desirous to test the relative feeding properties of turnips grown on different manures, I selected 4 imperial acres, in the centre of a 30-acre field, on the home farm of Clandeboye, for the experiment. The soil, as will be observed by the analysis, is of fair quality for the growth of turnips, sloping to the east, and at an elevation of 220 feet above the level of the sea. The preceding crop was oats after flax; the field having been all thorough drained in 1846, and the condition of the land perfectly equal; the oat stubble having been deep ploughed in November 1852, and in April and May 1853 the field was prepared by harrowing, one ploughing and harrowing, one grubbing and harrowing, and rolling. The weather during May was very dry and unfavourable for sowing turnips, which prevented the sowing during that month. On the 4th June we commenced sowing, and had reached the centre of the field by the 7th, when we had a change of weather with showers of rain favourable for sowing turnips, and on the 8th June the 4 lots were sown with Skirving's purple-top Swedish turnip-seed, on the following manures:—

Lot No. 1.—Manured with 24 tons Farmyard Manure.
Lot No. 2.—Manured with 12 tons Farmyard Manure and 2½ cwt. Peruvian Guano.
Lot No. 3.—Manured with 5 cwt. Peruvian Guano.
Lot No. 4.—Manured with 12 tons Farmyard Manure and 12 bushels Bones.

Each lot of one imperial acre contained 24 drills, drawn off at 28 inches apart. The manures having been all carefully

weighed, the different kinds as well as the soils and turnips have been analysed by Professor Hodges, of Queen's College, Belfast. The lots were all a good braird on the 18th June, and were singled 12 inches apart on the 12th July, at which date lots Nos. 1 and 2 were rather in advance of lots Nos. 3 and 4; by the 1st August lot No. 2 appeared rather in advance of lot No. 1, both lots looking well; lot No. 3 decidedly behind in appearance; lot No. 4 inferior to Nos. 1 and 2, but superior to No. 3; by October No. 1 appeared to take the lead, No. 2 nearly equal, No. 4 next, and No. 3 greatly behind in appearance. The season of 1853 having been very unfavourable for turnips in Ireland, consequently the produce of these 4 acres is much under our average weight of turnips in ordinary seasons. The cattle for this experiment were 12 heifers, half-bred short horns, $2\frac{1}{2}$ years old, which were purchased at Carlingston Bridge Fair, County Meath, on the 19th November, 1853, at 11*l.* each; they were home here on the 21st, and were turned into a grass field and had a few turnips given them daily; on the 2nd December they were put into a very good, well-constructed feeding house, with stalls for 12 head, and allowed Swedish turnips, hay, and straw; they having been all accustomed to turnips, they all commenced to feed well; thus every precaution was taken to give them a fair trial when the experiment would commence. On the 12th December I had the 12 heifers divided into 4 lots, of 3 in each lot, had them numbered, and each animal weighed, the gross weight of each lot being nearly equal, as will be observed by the following Table :—

TABLE showing the Live Weights of 12 Heifers fed on Turnips grown on different Manures during a period of 132 Days.

Description of Food.	Live Weight of 3 Heifers on the 12th Dec.			Live Weight of 3 Heifers on the 11th Feb.			Live Weight of 3 Heifers on the 24th April.			Increase of Live Weight during 132 Days.			Quantity of Turnips used by each Lot.			Quantity of Turnips used by each Heifer per Day.		
	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.
Lot 1.—Fed on Turnips grown with Farmyard Manure	27	1	7	31	2	0	35	2	0	8	0	21	237	0	0	0	2	11
Lot 2.—Fed on Turnips grown with Farmyard Manure and Guano .	26	2	14	29	3	0	32	3	0	6	0	14	219	1	0	0	2	6
Lot 3.—Fed on Turnips grown with Guano .	26	2	14	29	2	0	33	1	14	6	3	0	226	1	7	0	2	8
Lot 4.—Fed on Turnips grown with Farmyard Manure and Bones .	27	2	21	31	0	7	34	3	0	7	0	7	222	3	0	0	2	7

On the 16th December portions of each lot of turnips were lifted and well cleaned of tops, roots, and clay, and carted home, weighed and put up in the separate lots for the cattle, and on

the 2nd and 3rd February the whole of the 4 lots were lifted, carted home, and weighed. The weights of well cleaned sound bulbs were as follows, viz.:—

	Tons.	Cwt.	qrs.	lbs.
Lot No. 1, with 24 tons Farmyard Manure produced of Bulbs	18	3	0	14
Lot No. 2, with 12 tons Farmyard Manure and 2½ cwt. Peruvian Guano produced of Bulbs	17	14	3	0
Lot No. 3, with 5 cwt. Peruvian Guano produced of Bulbs	12	8	1	0
Lot No. 4, with 12 tons Farmyard Manure and 12 bushels Bones produced of Bulbs	16	0	0	14

The above lots were kept entirely separate from any other turnips, and in charge of a man who did not feed the heifers, but whose duty it was to have the daily allowance of each separate lot cut, and put into their respective places, so as no mistake could occur with the feeding. I may here remark, that during the experiment the heifers all fed remarkably well, and were very healthy. They were fed three times a-day; at 5 o'clock in the morning they got one-third of their turnips; having finished them, they got each 4 lbs. hay; at 10 o'clock forenoon they got the same, and at 3 o'clock afternoon they got the remaining third of the turnips, and 6 lbs. oat-straw each; after each feed the house was well cleaned, and their beds made up with dry straw; at the forenoon feed the cattle were well cleaned with comb and brush; the appointed times of feeding were strictly attended to, and nothing allowed to disturb them from rest except at their regular feeding times.

At the end of the experiment the 12 heifers were sold to Mr. Thomas Gaffikin, butcher, Belfast, at 18*l.* each. It will be observed that these heifers were purchased on the 19th November, 1853, at 11*l.* each, and valued at 12*l.* each when put up to feed on the 12th December, making 6*l.* on each heifer for 132 days' feeding, each lot consuming the following quantities of food, viz.:—

Description of Turnips.	Turnips consumed by 3 Heifers during 132 Days' Feeding.			Hay used by 3 Heifers during 132 Days' Feeding.			Straw used by 3 Heifers during 132 Days' Feeding.			Increase of Live Weight during 132 Days' Feeding.			Increase of Value of 12 Heifers for 132 Days.
	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	Cwt.	qrs.	lbs.	£. s. d.
Lot 1.—Grown with Farmyard Manure	237	0	0	28	1	4	18	0	0	8	0	21	
Lot 2.—Grown with Farmyard Manure and Guano . . .	219	1	0	28	1	4	18	0	0	6	0	14	72 0 0
Lot 3.—Grown with Guano . .	226	1	7	28	1	4	18	0	0	6	3	0	
Lot 4.—Grown with Farmyard Manure and Bones . . .	222	3	0	28	1	4	18	0	0	7	0	7	

The lot No. 1, fed on turnips grown upon farmyard manure, consumed 17 cwt. 3 qrs. more turnips than lot No. 2, and

increased in live weight 2 cwt. 7 lbs. more; again, lot 1 consumed 10 cwt. 2 qrs. 21 lbs. more turnips than lot No. 3, and increased in live weight 1 cwt. 1 qr. 21 lbs. more; again, lot 1 consumed 14 cwt. 1 qr. more turnips than lot No. 4, and increased in live weight 1 cwt. 14 lbs. more, giving an increase of 1 lb. live weight for every 29 lbs. turnips grown upon farmyard manure, and 1 lb. live weight for every 35¾ lbs. turnips grown upon farmyard manure and guano, and 1 lb. live weight for every 33½ lbs. turnips grown upon guano, and 1 lb. live weight for every 31½ lbs. turnips grown on farmyard manure and bones. Taking the 4 acres of turnips in this experiment, the following would be the increase of live weight upon the cattle for each acre:—

Lot No. 1	would give	an increase of	1402 lbs.	of Live Weight.
Lot No. 2	,,	,,	1111 lbs.	,,
Lot No. 3	,,	,,	830 lbs.	,,
Lot No. 4	,,	,,	1138 lbs.	,,

The expenses of working the 4 acres of turnips were equal, and the cost of manuring as follows, viz.:—

	£.	s.	d.
Lot No. 1.—Manured with 24 tons Farmyard Manure at 4*s.* per ton	4	16	0
Lot No. 2.—Manured with 12 tons Farmyard Manure at 4*s.* per ton = 48*s.*; and 2½ cwt. Peruvian Guano at 12*s.* = 30*s.*	3	18	0
Lot No. 3.—Manured with 5 cwt. Peruvian Guano at 12*s.* per cwt.	3	0	0
Lot No. 4.—Manured with 12 tons Farmyard Manure at 4*s.* per ton = 48*s.*; and 12 bushels Bones at 2*s.* 6*d.* = 30*s.*	3	18	0

From the foregoing it will be observed, that the farmyard manure produced the heaviest crop of turnips, and that the three heifers fed upon them made the greatest increase. Taking the relative feeding value of the crops of the 4 acres of turnips, the farmyard manure is in advance, farmyard manure and bones next, farmyard manure and guano next in value, and guano alone deficient. Although the heifers were sold at an average price of 18*l.* each, the difference in their value was in proportion to their live weight. It was remarked previously that the turnip crop of 1853 in this country was much under an average in weight, but it will be observed they were of fair feeding qualities, there scarcely being a deficient turnip on the 4 acres. This experiment shows that the cattle increased in value, in 132 days' feeding, 6*l.* each on the average, which is considerably above our average increase in ordinary years. The heifers were of fine quality, and in good condition when put up to feed, and improved remarkably fast, considering the small quantity of turnips consumed by them. The price of beef was also higher when the heifers were sold,

than when they were purchased. It will also be observed by the analysis, that the guano was not of the best quality of Peruvian. With these remarks I herewith give you Professor Hodges's analyses of the soils, manures, and turnips referred to in this experiment.

Composition of Soil and Subsoil from Mr. Templeton.

	Soil.	Subsoil.
1st. *By Washing:*—		
Clay, Fine Sand, and Organic Matter ..	24·29	32·75
Coarser Sand	75·71	67·25
	100·00	100·00
2nd. *By Analysis:*—		
Organic Matter	6·20	3·75
Oxide of Iron	4·21	6·69
Alumina	4·49	4·78
Phosphoric Acid	0·03	0·02
Sulphuric Acid	0·01	0·01
Chlorine	0·10	0·06
Carbonate of Lime	1·05	0·64
Carbonate of Magnesia	0·48	0·18
Alkaline Salts	0·08	0·03
Insoluble Silicious Matter	83·49	83·49
	100·14	99·65
Water in samples analysed	4·90	3·20
Nitrogen per cent.	0·17	0·16

Determination of Water, Ash, and Nitrogen in Turnips from Mr. Templeton.

	Number 1.			Number 2.		
	Outside.	Inside.	Mean.	Outside.	Inside.	Mean.
Water	87·86	89·43	88·64	88·81	88·87	88·84
Ash	0·59	0·78	0·67	0·48	0·73	0·61
Ash calculated dry . . .	4·87	6·74	5·80	4·29	6·56	5·42
Nitrogen ,, ...	..	..	1·30	..	..	1·42
	Number 3.			**Number 4.**		
	Outside.	Inside.	Mean.	Outside.	Inside.	Mean.
Water	87·45	88·21	87·83	88·50	89·05	88·78
Ash	0·63	0·67	0·65	0·48	0·51	0·50
Ash calculated dry . . .	5·02	5·69	5·36	4·17	4·66	4·42
Nitrogen ,, ...	..	..	1·78	..	..	1·82

Composition of Farmyard Manure from Mr. Templeton.

Water	75·560
Organic Matter	23·520
Potash	0·035
Soda	0·018
Chloride of Sodium	0·062
Lime	0·052
Magnesia	0·027
Oxide of Iron	0·045
Sulphuric Acid	0·027
Phosphoric Acid	0·045
Carbonic Acid	0·018
Silica	0·161
Sand	0·440
	100·010
Nitrogen	1·21

Composition of Bones (from Hodges's Lessons in Chemistry).

	lbs.
Organic Combustible Matters	33¼
Incombustible Matter or Ash consisting of—	
Phosphate of Lime (bone earth)	55½
Phosphate of Magnesia	3
Carbonate of Lime	3¾
Salts of Soda	3½
Fluoride of Calcium	1
	100

Composition of Guano from Mr. Templeton.

Water	7·20
Organic Matter and Ammoniacal Salts	54·10*
Alkaline Salts, containing 3·5 of Potash	9·80
Phosphates of Lime and Magnesia	22·60
Carbonate of Lime	1·10
Insoluble Silicious Matter	5·00
	99·80

JOHN F. HODGES, M.D.

Laboratory of the Chemico-Agricultural Society of Ulster.

The 4 acres experimented upon was ploughed in February for oats; the seed, potato oats, was put in with the drill on the 17th March, 1854, the land being in fine condition for receiving the seed. The lots all made a good appearance during June; lot No. 1 commenced making the best appearance, lot No. 2 next, lot No. 4 next, and lot No. 3 considerably behind in appearance. The 4 lots continuing that appearance till harvest, last harvest being remarkably fine weather, each lot was cut

* Capable of yielding 13·73 of Ammonia.

precisely at the same stage of ripeness, and each lot allowed to stand 7 days before thrashing.

The following Table of grain-crops shows nearly the same results from the different lots as the turnip crop:—

TABLE showing the Dates the Oats were Cut, Thrashed, and quantities on each Imperial Acre: Oats valued at 10*s.* per cwt., and Straw at 1*s.* 6*d.* per cwt., the Market-price at date of Thrashing.

Time they were Cut.	Time they were Thrashed.	Produce of Oats per Acre.	Produce of Straw per Acre.	Weight of Oats per Bushel.	Value of Oats per Acre.	Value of Straw per Acre.	Value of Grass-crop per Acre.
		Cwt. qrs. lbs.	Cwt. qrs. lbs.	lbs.	£. *s.* *d.*	£. *s.* *d.*	£. *s.* *d.*
Lot 1.—Sept. 6	Sept. 13	25 2 14	61 2 0	42	12 16 3	4 12 3	17 8 6
Lot 2.—Sept. 9	Sept. 16	23 2 14	55 0 0	40	11 16 3	4 2 6	15 18 9
Lot 3.—Sept. 16	Sept. 23	22 2 0	42 0 0	39	11 5 0	3 3 0	14 8 0
Lot 4.—Sept. 12	Sept. 19	24 0 14	51 0 14	41	12 1 3	3 16 8	15 17 11

In conclusion, it has been the object of the writer to make these experiments as free from fallacy as possible (having superintended the whole proceedings), and to allow the reader to draw his own conclusions: it will be easy for any one into whose hands these Tables may fall to arrange the results, and a comparison of these with similar experiments can hardly fail to afford interesting matter for reflection and continued experiment.

XI.—*On the Causes of Fertility or Barrenness of Soils.* By JOHN COLEMAN.

PRIZE ESSAY.

THE causes which operate in producing the fertility or barrenness of soils have hitherto to a great extent been shrouded in mystery, not from want of study, but owing to the difficulties which meet the inquirer at every step, and the fact that most important results frequently depend upon causes which have eluded the search of the experimenter. The science of chemistry it was hoped would afford the key, wherewith to unlock the mysteries of nature; but though its discoveries have conferred much practical benefit on the agriculturist, it has, up to a very recent period, effected comparatively little towards settling the causes of fertility or sterility. The theories of scientific men led us to expect, that fertility depended upon the presence of certain mineral substances, which were found invariably present in the ashes of plants; and the analysis of a soil it was believed would confirm the practical experience of the farmer: these hopes have been falsified except in the few cases of almost simple

soils, such as pure clays and sands. In all other instances, the analysis presented the existence, in varying proportions, of those substances supposed to induce fertility, equally in the barren as the fertile soil. The proportion of the various ingredients was next proposed as the sign of quality; but researches into the amount of inorganic matter abstracted by each crop have demonstrated that soils of a mixed character contain abundant supplies of mineral food for numerous crops. It is probable that fertility depends, more upon the peculiar condition of the saline matters, than their actual presence or absence in a soil; thus for example, we can imagine a clay soil, so full of water, that the air could not penetrate, and act upon the various salts, which, though of the right kind, might be in an insoluble and therefore useless condition; but the same soil, subjected to thorough drainage, and pulverization (physical change of its particles), might become very fertile, owing to the reviving influence of atmospheric action, and the increased temperature which would follow removal of the water, &c. It is for these reasons that fertility often appears to depend more upon physical than chemical causes, whereas the two are intimately combined: for instance, a pure sand may be physically in the best possible state, porous, warm, capable of retaining moisture, and yet totally barren from the absence of those chemical compounds upon which the plant feeds; and, vice versâ, the storehouse may be full, nature's laboratory may contain abundance, and yet the physical condition may be such, as to prevent those farther changes requisite, before the food can be fit for use. Before entering more particularly into an examination of the physical properties of soils, it may be as well to glance very briefly at their origin. Soils are derived from three sources: First, from the decomposition of the rock on which they rest. Secondly, from the decomposition of a drift formation, to which, in earlier days of geologic knowledge, the term Diluvium was applied, on account of their supposed formation by the Noachian Deluge; a view long since found untenable, and the name has given place to that of erratic tertiaries, because most of these beds seem referrible to a period posterior to the tertiary deposit. Various theories have been broached to explain their formation; the most plausible refer them to a period immediately preceding the present, when the earth was about to emerge from its watery covering, and when the natural elevations of its surface would cause mighty currents, carrying away in their course vast quantities of matter from the higher points, depositing them according to gravity at nearer or greater distances from the parent bed: the heavy matters would be deposited first, afterwards the finer and lighter ones. The direction of these currents seems to have been

generally uniform, extending in this country from the north and west: consequently we find the post-tertiary erratics ranging from the west and north, towards the east and south, fringing the western coast up the valleys, extending into Scotland, on either side of the Pennine chain or central ridge of England, which appears in most cases to have formed a barrier to further progress, though this is occasionally surmounted in the lowest spots. The character of these deposits, and consequently the soils found upon them, present every variety of form and nature, from the blowing sands to the huge boulder stones, from the fine arenaceous to the coarse gravelly soil. Thirdly and lastly, soils are derived from alluvial deposits, found occupying the line of most of the great rivers in this country. Accumulated by water, in its passage through various strata, they are of a very mixed and fertile character, especially near the mouths, where the currents of salt and fresh water mingling caused the death of multitudes of Infusoria, which sinking down were deposited along with fine mud, and affect the value of these soils to a considerable extent: similar processes may be seen going on at the mouths of many rivers at the present day. The sedimentary deposit has, in more than one instance, been turned to advantage by damming up the stream, and retarding its onward progress, until all the materials gathered together during its long journey through various strata were deposited as mud; when it was allowed slowly to pass off into the sea. Much land of the first quality has thus been gained both at the mouth of the Humber and in the Netherlands; in the latter country great expense and untiring energy are exhibited in preserving the valuable acquisitions from the ravages of the sea: works of great cost having been erected in the form of walls and barriers, the occasional destruction of which, and consequent inroad of the sea, is regarded as a national calamity. Considerable tracts of alluvial soil occupy the valleys of our principal rivers, such as the Thames, the Severn, the Avon, the Trent, the Dee, and the Mersey; varying in physical and chemical characters, according to the nature of the beds from whence derived. Thus a tract which occurs on the sea-coast, extending from Lynn to Barton in Lincolnshire, is a rich sandy loam, containing considerable quantities of animal matter; while the alluvium on either side of the Thames, in the neighbourhood of London, is of a clayey nature; but, however they may differ, the general character is great richness, due to their depth, fine state of division, and complicated nature.

From whichever of the above sources soils are immediately derived, they are all primarily produced by the decomposition of the older rocks. Thus the granite, upreared into mountain

chains and lofty hills, bare, rugged, and incultivable, is the parent of the rich soils found in the surrounding valleys; indeed all clay soils have resulted from the decomposition of granites containing felspar. Most soils are formed by the decomposition of the beds beneath, assisted by the deposit of animals and the growth and decay of vegetable matter. The principal agent is moisture, which swells out the particles, diminishing the cohesive attraction, and preparing the way for the chemical and mechanical action of the atmosphere, which gradually separates the various substances from previous affinities, and prepares, by new combinations, food for the vegetables which speedily appear. How the plant first originates, is often mysterious; whether a seed may be transported by birds, or whether nature has the power of spontaneous production, is a question which might form subject for curious and interesting investigation, but which is quite foreign to the present paper. Yet I cannot forbear mentioning a fact, which I have from good authority, as it goes some way to prove the latter hypothesis. The shepherds of the moors in Scotland are sometimes in the habit of firing the heather; the ashes remain on the surface; without any seed being sown, a rich herbage of Dutch clover springs up.

The lower forms of vegetable life first appear in new land, or more properly, in disintegrated rock, and by their roots clinging to and intersecting the mass, as well as by the protection afforded to the surface against the destructive effect of heavy rain, &c., materially assist in the process of forming a soil.

The action of frost is also very important, the expansion of the moisture in the soil or rock breaking up the particles, and preparing the way for the chemical forces to act: these are chiefly the oxygen of the air and carbonic acid gas, dissolved in rain water; both possess powerful affinities for many mineral substances—oxygen forming oxides, generally more soluble and looser in nature than the original minerals; carbonic acid acting upon lime, magnesia, and the alkalies, destroying previous combinations, and forming soluble carbonates.

The character of a soil will depend upon the nature of the parent bed; thus soils from granite consist principally of silicate of alumina, with soluble alkalies and iron, all more or less clayey in nature and destitute of lime. The soils from the chalk (especially the upper beds) contain large quantities of carbonate of lime with alkalies and iron, but very little clay, and form light free-working soils. In the former case, the felspar of the granite is the substance from which the clay soil is derived. Felspar consists of:—

Silica	64
Alumina	20
Potass	11
Lime (traces).	
Oxide of iron	1·75
Water	2·75
	99·50

It is found impossible to classify soils geologically, because the beds vary so extremely, and the soil has so frequently been derived from various sources; therefore we have recourse either to physical or chemical distinctions: the former being most easily recognised are usually adopted.

I.—Mechanical distinctions of Soils, as cohesiveness or porousness, coarseness or fineness of granulation.

We are in the habit of speaking of soils as light or stiff, loamy or marly, yet from such descriptions little correct knowledge of their real nature can be gained. It is true that the primary forms of soil, such as stiff clay, pure sand, chalky or peaty soils, may be well expressed by such terms; but in nature we have most frequently to deal with combinations of the above in the most varied proportions; very frequently the distinctive characters are completely masked from observation, so that the appearance alone would often lead to very erroneous judgments on the qualities of soils. A good classification based upon the physical condition and chemical combinations of the various ingredients is much wanted. In the absence of such I shall adopt the faulty method of dividing all soils into four groups, bearing the names of their chief constituents:—

Argillaceous or *Clay soils,* so called because clay (*argilla*), or alumina, forms the principal ingredient. Sir Humphry Davy considers the term should only be applied to such as contain above 1-6th of impalpable matter which does not effervesce in the presence of an acid. This division is again divided many times according to the presence of other substances, such as sand, lime, or peat, causing variations from the original type.

Silicious soils are those which contain a large amount of silica or sand in an uncombined state. Davy considers the term applicable only to soils containing 7-8ths of their bulk of sand. Perhaps this is going too far; we may with more propriety allow upwards of 70 per cent. as the minimum quantity.

Calcareous soils contain a large proportion of carbonate of lime, above 20 per cent.; and lastly,

Humous or *Peaty soils,* which include all that contain above 5 per cent. of vegetable matter. Such soils generally result from

the decomposition of peat bogs: they are easily recognised by their dark colour and small specific gravity. We shall proceed to consider these divisions in detail.

Clays.—These soils are very tenacious, due to the alumina. Plastic when moist, they are readily moulded into any form, hence their value for the manufacture of earthenware, and the purer and least productive soils are best adapted for this purpose. When dry, clay falls down into an impalpable dust, but in nature clays generally bake, that is, dry on the surface, but remain moist underneath, forming masses as hard as iron and very difficult to cultivate. The contracting influence of heat causes these soils to crack during dry weather; the fissures thus formed are often of considerable size, due to the closing of the particles kept apart by the moisture, which clay so readily absorbs. The presence of moisture, by excluding the atmosphere and the sun's rays, and by constant evaporation from the surface, causes clay soils to possess a lower temperature than any other; they are eminently cold in a natural state. This property of absorbing and retaining moisture and gaseous matter, which may be turned to the first advantage under judicious management, often renders clay soils unfit for cultivation in a natural state. The term heavy as applied to clay soils is not in reference to their specific gravity, which is less than sands or calcareous soils, but in consequence of their consistency making them difficult to work. Their agricultural value varies extremely, depending principally upon the proportions of the various ingredients as affecting the physical and chemical character, and we have examples of the poorest as well as most fertile soils. Pure clay does not enter into the composition of plants, nor as far as we know (except in very minute quantities) is it decomposed into its elements; consequently a soil consisting of it only would be perfectly barren although possessing great powers of absorption. Poor clays are the least desirable of all soils, on account of the heavy expense of cultivation, three and more often four horses being required for even the shallowest ploughing. Great judgment is required to know the proper time to work such land; as in wet weather the pressure of the hoof will puddle the subsoil into pans of the most impervious character. Fortunately very few are so simple in their nature as to be unfit for cultivation. More frequently the poverty is due to the saturated condition of the mass preventing the atmosphere penetrating and effecting those changes in the ingredients (thus rendered inert) which are indispensable before food can be provided for the plant. Before expending capital in reclaiming, it is highly important to ascertain whether the ingredients are of a nature to warrant it, and here we perceive an instance of the important assistance afforded

by the science of chemistry, informing us, as it does with full certainty, what the soil contains and whether it is likely to yield a fair return for our capital. Having satisfactorily settled this point, we may fearlessly proceed to invest our money, first by thorough drainage, and afterwards in pulverising, so as to admit the atmosphere, which readily takes the place of the moisture removed by our drains. Any advice as to the best methods of draining would be out of place here, and, it is to be hoped, unnecessary; since landowners and intelligent occupiers are by this time firmly persuaded of the vital importance of deep drainage, and the utter absurdity of placing the drains just beneath the plough-bed, as was the practice 20 years ago. The advantages are incalculable: cultivation is lightened very often one-horse-power; the temperature is raised; germination more rapid and certain; harvests accelerated ten days to a fortnight; supplies of food often apparently inexhaustible are eliminated, which would otherwise have lain dead and useless; and the number and variety of crops increased. The surface ceases to bake or puddle, hasty downfalls find ready access, and instead of standing on the surface, stagnating in the subsoil, or running off with the best parts of the soil, the rain-water quietly passes away into the drains, fertilising in its passage. It may be stated as a rule that all real clay soils resting on an impervious subsoil, whether in tillage or pasture, require drainage; without it they must be looked upon as the least remunerative, by its aid and judicious cultivation they may be rendered among the most productive.

The practice of paring and burning the surface of stiff clays, much followed in some districts, may be noticed as bearing on the physical condition of such soils. The operation is usually performed at that period in the rotation when the land contains the most rubbish, as all surface weeds, insects, &c., are destroyed by the fire. The process is very simple. A paring-plough, either drawn by horses or pushed by men, slices off about 2 inches of the surface, turning it over, in which state it remains till thoroughly dry. It is then got together into small heaps and burnt; afterwards the ashes are spread and ploughed in. If lime is present in any quantity, the first shower causes the ashes to fall in a coarse powder, which gets thoroughly incorporated with the soil, the lime furnishing valuable food both directly and indirectly to the succeeding crop. The effect of burnt clay is principally mechanical, opening the soil and rendering it more porous. It was formerly believed to absorb ammonia from the air, but recent experiments throw doubt upon this. The practice is found to answer exceedingly well, and, even if we do not burn the soil all over the field, we should never neglect any opportunity of obtaining burnt earth. Borders of hedgerows, cleanings-

out of ditches, and corners of fields, present excellent material for the purpose.

The principal clay districts in this country are those of the London and Plastic beds, occurring in the south-eastern counties; the Wealden, found in parts of Surrey, Sussex, and Kent; the Lias, forming a narrow band, which runs from S.W. to N.E. right through the country from the Vale of Gloucester to Yorkshire; the clays of the Old Red Sandstone, occurring in Devonshire; and the clays of the older rocks, developed principally in Wales. Besides the above a number of smaller beds occur, as clay is found in almost every formation; indeed, very few soils are devoid of some portion. We have hitherto spoken of those soils which contain a large proportion of clay; the most fertile districts contain clay mixed with certain proportions of sand, known as clay or sandy loams. The value of such soils consists in their containing sufficient absorbing and retentive power for vegetation, at the same time being open and to some extent porous: in fact, Nature has in these cases prepared the soil and saved much of the labour necessary to the stiffer clays. When resting on a porous subsoil, clay loams do not require draining. In other cases it is only necessary to remove the superabundant moisture in order to have a soil in every way fitted for the wants of plants. Such soils turn up as a fine mould, into which the atmosphere has ready access, and the roots can throw out without impediment. Clay loams should be looked upon as the standard to which by energy and capital we are to bring the stiffer beds; and though in the absence of sand it is vain to hope for the permeable and mouldy character, yet it is astonishing what alterations the strongest soils are capable of under judicious management. The addition of sand to clay would be very beneficial, but the great quantity required to make any alteration unfortunately prevents this being carried out.

Silicious or Sandy Soils.—This term is applied to all soils principally composed of silicious matter, either in the form of fine sand or of coarser sand and gravel. They possess qualities the very opposite of the last class, being light in colour, varying from a white silver sand to a rich red, exceedingly porous. In reality heavier than clays, they appear light from the absence of all cohesiveness. They neither attract gaseous matters from the atmosphere nor retain the manures put into them; hence the poorer and purer descriptions are known as hungry soils, and are barren and unprofitable to cultivate. Not retaining moisture and being so permeable, these soils are warm; the heat, too often rendered latent by evaporation in a wet soil, is enabled to penetrate and warm every portion, rendering them peculiarly suitable for rapid germination; the seed never lies long in the ground, provided there is sufficient moisture. I have known swedes,

drilled with a solution of superphosphate, appear above ground in three days, and commonly in a week; whereas on cold soils it is usually a fortnight before they can be seen. Harvests are much forwarder for the same reason; there is often the difference of from 10 days to a fortnight between sandy and clayey soils—a very important fact in our variable climate. As these soils do not retain moisture, and possess only slight capillary powers, they are subject to burn up with long-continued drought, and hence are very uncertain in their produce. In dry seasons the spring corn is often a miserable failure, the straw about a foot long, and the yield little more than the seed sown. The root crop for the same reason can seldom be depended upon. In a moist climate, by the aid of stimulating manures, a crop is pretty certain, but in other cases vegetation is often prematurely arrested and mildew attacks the leaves, preventing further growth. Very nice management is required, exactly the reverse of that necessary for the clays; in cultivating the latter our object is to loosen and render as friable as possible, for which purpose we plough repeatedly, dress with long half-rotted manure, and burn the surface into ashes. On sands we plough but little and sow the seed immediately after the plough, so as to receive the benefit of the moisture which is brought to the surface, repeatedly roll and consolidate by every means in our power, until we so force the particles together as to enable the soil to retain the moisture better. Owing to the absence of resistance, cultivation of sandy soils is very easy; single horses may often be seen at plough. A pair of quick light horses are equal to about 100 acres. The poorer kinds of sands, those that contain from 80 to 90 per cent. of silica, are nearly as undesirable as the very poor clays. In cases, however, where it is practicable, great advantages have followed the application of marl, clay, or chalk: this has been largely carried out in parts of Norfolk, the clay and marl being even brought from considerable distances; small quantities, comparatively speaking, are found when acted upon by frost and air to effect an alteration in the soil; the dose, however, should not be niggardly, at least 70 to 100 yards per acre, laid on the surface as early in the winter as possible, and not ploughed in until all chances of frost are over. By such means we may in time produce a sandy loam of considerable value. Natural sandy loams are often found occupying the valleys in sandy districts: they consist of a large amount of sand with a small, but sufficient, quantity of clay, and often lime, to remedy all those defects so apparent in the purer sands; and hence such soils are amongst the most valuable known, being adapted to the growth of almost every crop. Never wet, unless resting on a retentive subsoil, they yet retain sufficient moisture to keep the roots moist; not porous

like sand, they are still sufficiently open to allow of the air circulating through and warming them; easy of cultivation, they are ploughed with two horses. The clay protects from drought; the sand causes a high temperature. In some cases the sand is replaced by coarse gravel, a large quantity of iron being present; such soils, where the proportion of clay is large, are stubborn, and if cultivated when moist bind together and form masses very difficult to bring to pieces. Root crops grow well, though not equal to those on the sandy loams, and if fed off on the ground the latter is apt to become poached during wet weather, and the crop of barley often suffers. On the whole we should give the preference to the sandy loams.

The principal sandy soils in this country exist in the following districts:—In the South-east, forming portions of the Plastic Clay, commonly very poor and often resting on clay, wet; seen in parts of Surrey, Middlesex, and Berkshire.—Soils of the Iron and Hastings sand beds, belonging to the Wealden formation; very various in quality: where sand and iron occur without clay they are poor; where the latter earth is present, of very fair quality.—The soils of the Upper and Lower Greensand, occurring in Surrey, Hampshire, and the southern portions of the Isle of Wight. This series includes some of the richest, as well as poorest, soils in England. The former are found resting on the upper beds, and occur at Farnham, Selbourn, and the Isle of Wight. The powers of such soils are most extraordinary, due probably to a proper admixture of sand, clay, and lime, and the presence of soluble silicates—that is, silica united with certain alkalies in such proportions as are slowly rendered soluble by the action of rain-water. These soils are peculiarly adapted to the growth of wheat and hops, and produce bulky root crops. The soils of the lower greensand are the very reverse, generally consisting of fine sand, iron, traces of the alkalies, and scarcely any clay; they are light and very poor, in many districts unfit for cultivation. Large tracts are seen covered with gorse and heather; when a little better, they are frequently planted with larch and Scotch fir for hop-poles. Occasionally in the valleys a better soil is found, but even there it is weak, producing wretched pasture and very uncertain crops.—The Lower Greensand is seen in some parts of Surrey, especially the northern division, where it joins the Weald clay, forming a considerable range of hills, of which Leith is the highest point.—We pass on to the soils of the Old and New Red Sandstone developed in the Southern and Western counties. Taken as a class they form deep rich soils, and when clay is present in considerable quantities the finest oak timber land we have. The above, with a few smaller districts situated on the Silurian and primary rocks, form the principal sandy soils

found in this country, exclusive of those formed by alluvial and drift deposit. As before stated, they present great variety of colour, texture, and physical properties, and consequently every grade of fertility from pure sand, which is perfectly barren, to the richest sandy loams. As a class, they may be termed free-working, porous, warm, dry, and quick soils; but too frequently destitute or deficient in those important substances which are necessary to ensure the maturity of a crop. The very poorest are capable of great improvement by the addition of clay and lime; though, when the sand is coarse-grained, it is to be feared that these substances would in time pass away, and be lost in the subsoil. Perhaps it would be more judicious to leave such soils to a state of nature, and expend our capital upon such as, containing the elements of fertility, only require mechanical aid to unlock their treasures, and gratefully afford an ample return for our investment.

Calcareous Soils are those in which carbonate of lime predominates, either in a fine state of division, as in chalk soils, or as calcareous gravel or even large irregular fragments. With few exceptions, all true calcareous soils are free from excess of moisture, light in colour, porous, and resting upon an open subsoil, derived from disintegration of a hard rock or compact chalk; often only a few inches in depth, they are liable to burn up in hot dry weather. Subsoil ploughing, by gradually deepening the surface, is very beneficial, and should not be neglected. Where a certain quantity of clay is present, the soil is termed a marl, and becomes of improved quality, capable of carrying heavy crops of wheat and beans. On the thinner lands, barley and root crops answer well, provided the surface is kept sufficiently firm by sheep treading and rolling. Limestone soils possess very little cohesive attraction, and though good absorbents, are bad retainers of water. As in the case of certain sandy soils, too frequent ploughing, especially for the root crop, is very injurious; and I have seen an instance where the produce was reduced at least one-half from an extra ploughing. Calcareous soils, taken as a whole, are of a useful nature, adapted to a mixed husbandry, producing a sweet short grass suitable for sheep, and growing most crops, especially all those of a leguminous character. The root crop requires nice management, and is rather uncertain; still with judicious treatment and the application of artificial manures it need seldom fail. The soils of the chalk formation, found principally in the South and Eastern counties of England, form perhaps the most considerable and collected examples of calcareous nature. They are divided into two sorts, according as they are derived from the upper or lower beds: the former are usually poor, light, and full of flints; the latter possess more tenacity,

even marly towards the lower parts, contain no flints, and form very fertile soils. Various theories have been started to explain this difference: doubtless to a considerable extent it may be traced to the proportion of clay present, but also to the existence of alkalies and silica in a comminuted form, either combined as soluble silicates or existing separately in such a state as to become slowly soluble under the action of rain water. It has been calculated from analysis that about the same per-centage of silica is diffused through the lower chalk as is found collected together as flints in the upper.* To whatever due, the fertility of the lower chalk is so marked that in many instances it has been even brought from long distances at considerable expense and applied as a dressing to the soils of the upper beds. The soils upon the oolite formation form the other principal example of calcareous origin: they occur in narrow patches, from Somersetshire through the central part of England, up to Yorkshire, generally forming elevated land. Resting on a porous subsoil, they seldom require drainage. The depth varies according to the situation, whether on the hills or in the valleys, and the particular bed from whence derived; generally speaking shallow, but often resting on a brashy subsoil, capable of improvement by subsoiling. In the valleys occur useful soils, producing good cereal and leguminous crops; but on the hills the soil is thin, porous, and poor, requiring different management. Seed crops must be occasional only, and the land is usually rested with sainfoin, which remains down several years, and being a leguminous fodder-crop, seems specially adapted for calcareous soils. Owing, however, to the variety of beds which occur in close proximity, and often come to the surface on the same farm, the nature of the land varies on the most limited areas,—a circumstance of great value to the cultivator, who can adapt his cropping to the peculiarities of each

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* The difference in composition of the two beds is well seen by the following tables: the 1st is an analysis by Playfair, of the upper chalk from Norfolk; the 2nd, by Way, of the lower chalk from Farnham.

	No. 1.	No. 2.
Moisture	0·70	..
Carbonate of Lime	95·50	66·44
Silica (partly as Silicate of Potash)	0·51	26·09
Protoxide of Iron	1·70	3·04
Alumina	·64	
Sulphate of Lime	·37	..
Phosphate of Lime	·10	3·75
Carbonate of Magnesia	·19	·68
Chloride of Sodium	·13	..
Potash	traces.	..
Loss	·16	..
	100·00	100·00

field, and thus increase the productiveness of his land. Occasional draining may become necessary from the presence of a vein of clay between two porous beds; but this is generally a simple operation, as we can often empty the drain into the porous rock, without any fear of the waters reappearing. There are other considerable limestone soils, such as the mountain limestone, and many smaller tracts scattered over all parts of the country. The presence of a small proportion of lime is indispensable to every fertile soil, and as the quantity required is small, it forms a most important application to all soils that are deficient in this respect; it is used either as a carbonate in the form of chalk, limestone, &c., or in the caustic state, as quick lime. The operation of lime under the latter form will be best discussed when describing the chemical peculiarities of soils.

Peaty or Vegetable Soils are those in which decayed vegetable matter, or humus, forms the principal ingredient, or at least gives distinctive character. They vary very much (according to the quantity of humus, and absence or presence of other bodies), from the rich vegetable soils of the garden to the peat bog, which is often valueless until earthy matters, as clay, sand, or lime, are added. These soils are dark in colour, light and spongy in texture, and, though deficient in cohesive properties, powerful absorbents, and generally resting upon clay, require drainage before they can be cultivated. Peat also possesses a considerable retentive power itself, due to the undecayed cells of the vegetable matter, which retain and allow of the moisture rising to the surface by capillary attraction. Peat beds have in most cases resulted from the gradual decay of mosses, &c., under water until the continued growth and decay has reached the surface, when the whole mass assumed a semifluid state; the peat is not, therefore, generally very deep. When practicable, it is important to lay the drain in the substratum, as affording a sounder bottom and a better material for the pipes to lie in, as well as arresting the moisture before it can rise in the peat. The physical character of peaty soils varies considerably, depending upon the amount of decay they have undergone: when first brought under cultivation they are very open and cellular in structure, becoming finer and more mould-like by exposure to the atmosphere. The deposit of peat being very partial, the soils are limited in extent, the principal tracts existing in parts of Ireland, and in Lincolnshire and Bedfordshire, forming the Great Bedford Level.

The hasty glance we have thus taken of the principal classes into which soils may be divided will assist us in determining the importance of the physical properties they possess. The distinctive character of clay soils is their tenacity, dependent on the power of absorbing and retaining moisture. The relative power of various soils to absorb moisture was determined by Sir H.

Davy, who found that 1000 lbs. of the following, when thoroughly dried, gained by exposure to a moist atmosphere—

	lbs.
In the case of a fertile soil, East Lothian	18
,, ,, Somersetshire	16
Soil from Mersea in Essex, worth 25*s.* an acre	13
Sandy soil from Essex, worth 28*s.* an acre	11
Coarse sand, worth only 15*s.* an acre	8
Soil from Bagshot Heath (uncultivated)	3

The power of absorbing gaseous matters, such as carbonic acid, nitric acid, and ammonia, from the atmosphere, generally coincides with the quality of absorbing moisture, and therefore, though probably depending more upon chemical than mechanical agency, may be noticed here. The property of retaining moisture, which is valuable according to climatic circumstances, also appears to bear a close relation to the power of absorption. The following table has been obtained by taking equal weights of various soils, thoroughly drying, and adding water till each commenced dripping, then re-weighing the addition, of course showing the relative retentive powers of each; thus—

100 lbs.	of	pure clay became	170 lbs.,	thus gaining	70 lbs.
100	,,	clay loam	150	,,	50 ,,
100	,,	chalk	145	,,	45 ,,
100	,,	loamy sand	140	,,	40 ,,
100	,,	calcareous sand	129	,,	29 ,,
100	,,	pure sand	125	,,	25 ,,

The power of retaining moisture depends in a great measure upon the state of mechanical division of the atoms of the soil: thus a coarse sand, according to Schubler, only retains 20 per cent. of water, while a fine sand can hold 40 per cent. The same thing is seen in the case of fine or coarse calcareous soils. Humus is one of the best absorbents and retainers of moisture. A pure vegetable soil, formed by decay of wood, is capable of absorbing 200 and even in some instances 300 per cent. of moisture. The cohesive property is owing to the extremely fine state of the particles, and their attraction for each other increased by the presence of moisture. The amount or intensity of this quality in a soil is determined by the power required to separate a given mass. Schubler has found that taking the resistance or cohesiveness of pure clay as 100—

Sand	0
Fine lime	5
Humus	8
Sandy clay	57·3
Loamy clay	68·8
Arable soil	33·0

The difficulty of working clay soils is therefore owing to the resistance offered to the implement by the cohesive attraction of

the particles, and also to the adhesion of the soil to the implement, which differs in different soils—clays of course most—27 lbs. of pure clay adhering to one square foot of iron; 29 lbs. to the same surface of wood. This quality of cohesiveness in clay soils is of great importance, for although chemical forces may have much to do with fertility, yet, independently of such sources, it is owing to the cohesive powers and state of minute division of particles that we justly consider clay as by far the most important substance found in soils. As has been shown, these properties may be in excess, rendering the mass so compact and wet that neither air nor warmth can penetrate; healthy vegetation is then impossible, for if the germinating power be not suspended, growth is checked by starvation. But even these disadvantages are preferable to the opposite qualities of excessive porousness and looseness, inasmuch as we can remedy the one by artificial means, such as drainage and cultivation, but cannot improve the other without the addition of foreign matters, always a most expensive process. As all plants feed by roots as well as leaves, and can only receive food in solution, the presence of a certain amount of moisture is indispensable. When, therefore, we find clay united with such substances as have an opposite tendency, and which prevent the excessive influence of those qualities, we should naturally expect fertile soils; and such is pre-eminently the case from the union of clay and sand, or clay and lime. The distinctive character of sand being its porosity and inability either to absorb or retain moisture, when mixed with clay it tends to qualify the latter, and without injuring its useful powers, keeps the soil sufficiently open, allowing the water gradually to pass off, and thus, instead of the root being constantly surrounded by stagnant water and perishing from cold, it is supplied with a refreshing draught constantly renewed, equalizing the temperature, &c.; the soil retains its natural heat, which would otherwise be absorbed by evaporation, and the atmosphere is enabled to circulate and the sun's rays to penetrate, revivifying the soil and causing those wonderful changes which are as necessary to the health of the plant as pure air is to an animal. Lime acts much in the same way as sand, being of a very porous character; but possessing considerable absorptive powers, does not so thoroughly correct the retentive character of the clay. The cohesive property is of the first importance in estimating the fertility of soils by physical character. The porous property is also highly beneficial when acting as a check or diluent upon the former quality, but injurious when alone; its action is rather negative than positive. Soils, porous without being retentive or absorbent, are barren, or liable to become so from drought. They possess warmth and admit the air very freely—important qualities; but we might as reasonably expect

an animal to exist without food, if placed in a good atmosphere, as a plant to live without moisture. The amount of cohesiveness necessary for fertility depends upon climatic influences—a point too often lost sight of in agricultural examinations, since the rainfall varies in this country from 18 to upwards of 70 inches per annum. In a climate constantly moist much less retentive power would be necessary than in a dry air, where not one-third so much rain falls, and where consequently the soil must act as a reservoir. Limestone soils are often remarkably fertile in the former situations, whereas in the latter they are often poor, and readily affected by drought.

The fineness or coarseness of granulation of soils is another mechanical character of considerable importance. Fine soils retain moisture longer than coarse ones, probably because they offer greater obstruction to its passing away, and possess a higher capillary power. By this term we refer to the power water possesses of rising in the soil, apparently in opposition to the laws of gravitation. If we take a fine tube of glass and place the bottom end in water, the water will rise in it to a considerable height, standing highest at those points where it touches the glass, as though the water possessed a certain attraction for the glass and scrambled up by laying hold of the sides. The finer the tube the greater the capillary attraction. We must, therefore, regard the soil as consisting of a number of tubes, the walls formed by the particles of soil, and the hollow represented by the natural space between them. We must not confound this gradual rising of water with the rising of springs, as the latter results from the pressure of accumulated volume, which tends to force the water upwards till it reaches its former level. In dry seasons and climates the capillary power of a soil is often of great importance, as a steady supply of moisture is thus afforded to the roots long after the surface has become dried up. One of the great objects of draining is to prevent excessive capillarity by drawing off those waters, which would otherwise find their way to the surface in too great quantities, and lower the temperature of the soil by evaporation. Peaty soils possess considerable capillary powers; but clay surpasses all other soils in this respect. Limestone soils and coarse sands, being composed of larger materials, have little capillarity. Fine soils, being much firmer than coarse ones, present a better surface for the roots to attach themselves. The presence of considerable quantities of loose stones or flints in the latter often has a beneficial effect, in rendering them more solid, preventing the roots being thrown out by frost, sheltering the young plant, and shading the ground from the drying effects of a hot sun. The custom of picking off all stones from the surface is often a great error, as they exercise a beneficial influence, and

in many cases would in time disintegrate and deepen the soil. Of course they must be removed where so large as to interfere with cultivation; but the benefit is very doubtful in other cases. The presence of stones scours the plough, as it is termed, that is, keeps the share and turnfurrow clean.

Colour may be regarded as a physical character of soils, and may be noticed as appearing to exercise a marked influence upon fertility, due in a great measure to its affecting the temperature. Pedestrians are well aware of the difference felt in a very hot sunshine in walking over a white or dark soil. In the first case the rays are reflected and strike upon the body with uncomfortable force; in the second they are absorbed, and the ground, or rather air, appears cool and refreshing. The darker a soil the greater its absorbing power; but to compensate in some measure for this, the light-coloured soil retains heat longest.

II.—Chemical Characters, with General Account of the Results of Analyses hitherto made.

By the term chemical character of a soil, we refer to the presence or absence of those ingredients with which the science of chemistry has made us acquainted. The ashes of plants are made up of a number of mineral substances, varying in different kinds, but always identical in the same species; and as these matters must be derived from the soil, we should expect to find fertile soils abounding in, and barren soils destitute of them. This, however, is not always the case: of course fertile soils must possess them, but infertile also often exhibit abundance of such food, and therefore we believe their value may depend more upon the particular state of combination in which they exist, than merely their presence or absence in a soil. Chemical analysis often fails to detect substances, which may yet exist in sufficient quantity for vegetable life; or again, from some slight impurity in the re-agents, it may indicate bodies, that are absent from the soil. Owing to these difficulties, the science of chemistry has not produced those results which were naturally expected. Little reliance can therefore be placed upon the mere tabular results of an analysis, the object of which is to point out the relative quantities of the different mineral matters in a soil without reference to their state of combination. We do not wish to infer that no value is to be attached to the ordinary analyses of soils, but would only point out their liability to error. Fertile soils contain the following substances: silica, alumina, peroxide of iron, lime, magnesia, potash, soda, sulphuric, phosphoric, and carbonic acids, and chlorine. With the exception of alumina, all these exist in the ashes of plants, being built

up in the vegetable system, in union with organic matter; we shall therefore consider each shortly.

Silica, an oxide of the element silicon, possessing slightly acid properties, occurs pure in quartz crystals and many sandstones; forming the principal ingredient of all sandy soils, and being insoluble and destitute of all valuable physical properties, their poverty bears an exact ratio to purity. It is in combination with various bases, such as alumina, magnesia, lime, and the alkalies, that silica becomes an important element in soils. The straw of cereal crops contains a large quantity, giving strength and hardness. When wheat is too frequently repeated on a poor soil, the straw becomes weak, and goes down before the corn is ripe, because sufficient available silica is not to be had. The silicates are generally insoluble, and it is probably by their decomposition in the soil, that the silica, soluble in its nascent state, is taken up by the moisture present in the soil, and presented to the roots of plants. We say this is probable, because we can effect similar changes in the laboratory; but we should always remember that there are many counteracting influences in the soil, which may interfere with the result. In the most fertile soils, we find the largest amount of silicates united with alkaline bodies, in which form it is most readily decomposed. Lime is supposed to possess the property of setting silica free; whether this action is confined to quicklime only is still undecided. Chemistry here teaches the reason for rotation of crops, which practice had found necessary; the wheat crop, which takes most silica, is seldom taken above once in four years on poor land, and we precede and follow it with crops which remove very small quantities of this important substance. Silicates exist more abundantly in clays than in most sandy soils, consequently we find the wheat crop more frequently repeated: wheat after the fallow, is followed by beans, succeeded by wheat again; a rotation which would be impossible on sandy soils. Of course this difference is not to be traced to the silica only; many other substances are equally required, but none are more important.

Alumina is an oxide of the metal aluminium, possessing basic properties: it occurs abundantly in nature, forming, in a crystallized state, many of the precious stones; but its principal form is common clay, which is a silicate of alumina. It is not known to enter into the composition of plants, yet it must be regarded as the most important constituent of soils; partly due to its physical properties, and partly to the extraordinary affinity it manifests for gaseous substances, especially ammonia and carbonic acid gas. Pure clay like pure sand would form a barren soil; fortunately such do not exist in nature—clay being accompanied by various other substances, the relative proportions and combi-

nations of which determine the fertility of each particular soil. Clay forms a matrix in which all other substances act; it is a storehouse, in which are collected and brought into contact those bodies which possess an affinity for each other's society: having united together, they are taken care of until required, when they are slowly produced. Silicate of alumina unites with silicates of other earths and alkalies, forming what are called double silicates—substances which appear to play a most important part in the nutrition of plants.

Lime is also very abundant in nature, being found in all fertile soils; indeed, as it enters into the composition of every kind of plant, we may safely conclude that it is necessary to vegetation. It is an oxide of the metal calcium, possessing basic properties; having a great affinity for moisture and carbonic acid, on exposure to the atmosphere it rapidly becomes a hydrate, and finally carbonate of lime, in which state it principally exists in soils, though it is also found as sulphate and phosphate. From the earliest times lime either as carbonate or oxide has formed an important dressing for all kinds of land: whenever new land is brought into cultivation, or old pasture broken up, quicklime should be applied, whether the soil be stiff clay or light sand. We are better acquainted with the action of quicklime than of the carbonate, owing to its having engaged more attention from the chemist; but it is reasonable to suppose that the action is similar in both cases, only much more rapid and effective in the former, and therefore its application is to be preferred. As much less is required, the expense of burning is compensated by the saving in labour. Much difference of opinion still exists as to the action of lime; some chemists would limit its effects to vegetable matter only, others confine its action to the decomposition of mineral matters, while a third class look upon it principally as a manuring substance. We believe its value is due to all three causes. That lime has a most beneficial effect on inert vegetable matter is clear, from the advantages which follow its application to peaty soils; that inert vegetable matter exists in soils that have been long in cultivation and frequently manured is most certain; and that lime would in such cases prove as fertilising as a dressing of manure seems reasonable to conclude: but of course, as its effect is destructive, and in this sense dependent upon the presence of vegetable matter, it can never be substituted for manure. Its action consists in reducing to an available form those substances which have not been already absorbed by plants on account of their insoluble condition. This, it is now generally believed, is effected by the gradual reduction of the humus into its ultimate products, carbonic acid and water, and possibly ammonia or nitric acid; the nitrogen of the atmos-

phere uniting with the hydrogen set free in its nascent state. During this process it is probable that various organic acids are formed; passing rapidly one into another, without entering into plants as such. Lime removes the acidity often found in vegetable soils, either by destroying the acid, or combining with it to form an organic salt. Were the action of lime restricted to vegetable matter only, it could not fail to prove a most valuable application; but its relation to the mineral matters in the soil is perhaps more important still. In most stiff soils the alkalies are found united with silica and alumina, in certain proportions, mostly insoluble and therefore useless. Rain water, containing carbonic acid, might gradually dissolve out portions, sufficient for a natural condition, but inadequate to the artificial requirements of cultivation. Lime appears to possess the power of setting free the alkalies and magnesia from their insoluble condition, probably replacing them; and what seems rather extraordinary, is, that when these substances are added to the soil and would pass away too rapidly and be lost, by some means not yet clearly understood lime possesses the property of fixing them as insoluble compounds, causing their union with those very substances from which it had previously displaced them. Any attempt at explanation of these remarkable changes would be out of place here; but should the present discoveries be confirmed by further investigation, a most important fact must follow, viz., the advantage of repeated applications of small quantities of lime, and the wastefulness of the old system of heavy dressings. Lime enters into the composition of most crops, but the quantity required for this purpose is so small, and the natural supply in most soils so abundant, that we can hardly attribute the effects of its application to this cause. From all these facts, we should expect to find limestone soils a very fertile class, and when the other essential elements of fertility are present, such is the case. We are not certain that lime as carbonate acts in the same manner as in the caustic state; that its application to soils light and heavy, mineral and peaty, has been found beneficial is undoubted. Its influence may partly be ascribed to physical causes, making stiff clays more workable, sands more absorbent, and giving firmness to peaty soils.

Iron, being found in most crops, is an important ingredient of soils. It generally exists as peroxide, giving a red appearance. The protoxide appears to exert an injurious influence on vegetation; it is found in the subsoils of stiff undrained clays, giving the yellow tinge. On exposure to the atmosphere it absorbs oxygen, becoming peroxide. When such subsoils have been brought to the surface too suddenly, great injury has resulted, which is generally attributed to the protoxide of iron.

Phosphoric acid is a most important ingredient of soils, and its application when deficient has been most successful. It is a compound of oxygen with the metal phosphorus; it occurs united with various bases, as lime, magnesia, potash, soda, &c.; such combinations being known as phosphates. Phosphate of lime, the most common form, causes the high manuring properties of bones. In this state it is insoluble, but when the bones are digested in sulphuric acid, a chemical change takes place, and the resulting superphosphate, as it is called, contains a considerable quantity of soluble phosphate; hence its action is more rapid than simple bones; the latter are more lasting, and were formerly applied with the greatest advantage to worn out pastures. In this way the extensive dairy districts of Cheshire have been improved. For ages before, the milk (which contains a large percentage of bone earth) and the young stock sold off, had abstracted all the phosphates from the soil, and the pastures were yearly becoming more exhausted. There have recently been discovered certain soils on the upper greensand, very rich in phosphates derived from the decomposition of coprolites or fossil manure, and their fertility is very remarkable. The bed from which they are derived is quarried, and forms a most valuable manure.

Sulphuric acid is also found in the ashes of plants, and, united with various bases, exists in most soils. It has been found very beneficial when united with lime, as a top dressing for clover, especially on sandy soils.

Magnesia is the oxide of magnesium, possessing basic properties, and closely resembling lime in its nature. It occurs in most soils; all limestone rocks contain more or less as carbonate; sandy soils are most deficient, and its application to such in the form of sulphate (Epsom salts) has been found successful. The magnesian limestone consists of nearly equal parts of carbonate of magnesia and lime; many fertile soils are found resting on it, which seems to refute the prevalent opinion of its poisonous tendency, when existing in large quantities.

The alkalies, *Potash* and *Soda*, may be considered together, as they possess similar properties, and it is even believed are in certain cases capable of replacing each other in the cells of a plant. They are oxides of metallic bodies, potassium and sodium, and occur in the soil as salts, united with carbonic, silicic, sulphuric, phosphoric, or hydrochloric acids. The percentage of each found in plants is very small, yet their presence in the soil is most important; all plants contain them. The fertile nature of wood ashes is due to carbonate of potassa; sea weeds owe their manuring effects principally to the alkalies; clay soils are rich in alkalies, often occurring as silicates in an insoluble form,

but in such a condition as to become slowly available for vegetation; limestone soils, at least the poorer varieties, are deficient in these substances, consequently their frequent application in small quantities is desirable; they should be applied as a top dressing in spring, so that the roots may take them up before they pass away into the subsoil; guano and all other animal manures owe a portion of their effect to the alkalies present in them. The power of substitution supposed to exist in certain plants, has not been very clearly proved; it is said that sea-side plants which contain a large percentage of soda when grown inland, and upon soils rich in potash, have the power of absorbing the latter, and vice versâ, but further experiments are required to determine this interesting question, which is of great practical importance, inasmuch as soda in the form of chloride exists much more abundantly in nature than any salt of potassa, and could therefore be applied much more economically.

Chlorine is the last mineral constituent of soils we shall mention. It occurs in most plants, and, where deficient in the soil, should be added in the form of common salt. The application of this substance has much increased of late years, and the successful results obtained would warrant our believing, that besides its food value, common salt may possess some peculiar chemical power in assisting to make other matters available as food for plants.

The assimilation of the above mineral matters by the vegetable kingdom appears to depend upon the presence in suitable proportions of the organic elements, carbon, hydrogen, oxygen, and nitrogen. The three first are very abundant, and can be obtained both by the roots and leaves of plants; the nitrogen occurs more sparingly, and fertility appears to depend mainly upon its presence in the soil. Small quantities existing in the atmosphere as ammonia and nitric acid are carried down into the soil with every shower, or absorbed by the surface soil. This property of absorption is enjoyed in a different degree by different soils. The experiments of Professor Way, though not yet completed, have gone further to throw light on this important subject and to determine the real causes of barrenness and fertility of soils, than the investigations of all his cotemporaries or predecessors. Not content with ascertaining that certain soils possessed a power of absorbing and retaining ammonia, of which others were almost destitute, alone a very important discovery, he has most successfully demonstrated that this property is owing to the presence of a class of mineral compounds, termed double silicates, that is, silicate of alumina united with silicate of some other base, such as lime, soda, potash, or magnesia. The ammonia, possessing the power of displacing any of the above, takes

their place, forming a double silicate of alumina and ammonia—a compound almost insoluble in water, but slightly soluble in rain-water, which contains carbonic acid. By this process the volatile and soluble ammonia, not required for the immediate use of the plant, instead of being carried away in the water of drainage, or evaporating into the atmosphere, is stored up in the soil in such a manner as to allow of its being given up slowly when required. Moreover he found that salts of potash, in the same way, can displace any of the other bases named, but not ammonia. Magnesia follows next, then lime, and lastly soda, which being the least valuable because the most abundant, is displaced by any of the others. To use the Professor's own words, for the preservation of ammonia four compounds are made responsible, for potash three, for magnesia two, and for lime only one. We cannot fail to admire the beautiful economy of nature, which thus takes the greatest care of the most valuable substances. It was mentioned that the ammonia double silicate was only slightly soluble, and hence, it might be feared, would be too securely locked up to become available for the wants of plants; but Professor Way has discovered that lime, when brought into connection with the ammonia double silicate, causes it to be set free. Common salt also appears to possess the same property. May not this explain the well-known beneficial effect of small doses of salt and lime on clay soils for the wheat crop? It would be quite out of place here to enter into any detail of the course of experiments by which these results have been reached; they will be found most lucidly described in former volumes of the Journal. We have mentioned them because, if confirmed, they must exercise a great influence on the future progress of agricultural chemistry, and because they bear out what has been stated before, that it is to the peculiar state of combination, and not to the existence only of the various mineral substances in a soil, that its fertility or barrenness is due. Henceforward the point in an analysis will be, the proportion and description of the double silicates; and the advice as to manure, rotation of crops, &c., will depend upon this. For instance, suppose a soil deficient in double silicates, then addition, if practicable, would be the first point; if this could not be done, we should at least be aware of our weakness, and apply our manure in such a manner that the roots of our crop could absorb it before it passed away into the subsoil; we should not lay on large dressings as food for a succession of crops, but should rather aim at giving a small dose to each. Should our land, on the contrary, be rich in double silicates, we might fearlessly bury our manure, confident that the soil would preserve it, and annually or frequently topdress with small doses of lime and salt. Perhaps we ought not to place

too much confidence in the correctness of these views till confirmed by further experiments; though the character of the investigator for scrupulous care and unwearied perseverance is almost a guarantee for their truthfulness.

We have now to consider how far the general results of analysis, hitherto made, have benefited the practical farmer. Certain soils having been found peculiarly adapted to the growth of some plants and unsuitable for others, analysis ought to point out the reason for these peculiarities, and to a certain extent it has done so. But inasmuch as fertility or barrenness depends upon the state of combination in which the ingredients exist, quite as much as upon the actual existence of the various salts, and as analysis hitherto has generally been confined to pointing out this latter fact only, we ought not to feel surprised that chemical returns have often failed to bear out practical facts. Again we should bear in mind, that although we may in the laboratory prove the existence of the elements of fertility, and demonstrate their mode of action, yet these facts may be falsified in the soil, owing to the presence of other forces of which chemistry cannot take account. Professor Way has shown that a crop of wheat takes a very small quantity of mineral matter from a soil, and that many soils contain abundant supplies for a number of crops, yet in practice we can never take more than one crop in succession without injuring the land and weakening the produce. It is found that those very substances which analysis shows already existing in abundance, if added to the soil, produce good results. The reason for this discrepancy is doubtless owing to the particular state of combination as affecting the solubility or insolubility, and the fact that the roots of the crops come into connection with only a portion of the fertilising ingredients.

The chief value of analysis hitherto has consisted in pointing out those substances required as food for particular crops, their presence in or absence from the soil, and the cheapest form and best method of application when deficient; also in determining the relative value of the various manuring substances so constantly offered to the practical man, in discovering valuable manures in the refuse of manufactures which would otherwise be wasted, and in the discovery of fossil or earthy manures. Considering, therefore, that the science of agricultural chemistry is still in its infancy, the opinion that it has hitherto conferred no benefit upon agriculture is most unjust, and can only proceed from ignorance. We are already indebted to it for a general enlightenment as to the principles of vegetable life; and though at present it may not have produced very startling results, still it has opened up so many new views, that every man of sense will feel grateful for its assistance, and look hopefully forward to the future.

We proceed to give the analysis of a few soils of various kinds, commencing with that of a clay soil, from the upper oolite formation, near Cirencester, by Dr. Voelcker :—

Water driven off at 212°	5·53
Insoluble Matter (Clay)	84·10
Oxides of Iron and Alumina Sol.	3·07
Organic Matter and Water of Combination	3·62
Carbonate of Lime	·74
Magnesia	·60
Potash	·26
Soda	·22
Phosphoric Acid	·38
Soluble Silica	1·45
	99·97

In this analysis we are struck with the very minute quantity of the soluble in proportion to the insoluble matters, and might hastily judge such a soil to be very sterile, an erroneous conclusion, of which we shall at once be convinced if we bear in mind the very minute quantity required for each crop. Professor Way, who has paid great attention to this subject, informs us that the total weight of soil removed from an acre of ground by an average wheat crop only amounts to 277 lbs.; twenty crops taking 5540 lbs., or ·248 per cent. of the whole soil. He gives the following tables :—

	1 Crop.	20 Crops.	Percentage of Soil removed by 20 Crops.
	lbs.	lbs.	
Silica	170	3400	·152
Phosphoric Acid	30	600	·027
Sulphuric Acid	8	160	·007
Lime	16	320	·014
Magnesia	10	200	·009
Potash	40	800	·036
Soda	3	60	·003
	277	5540	·248

The following is the analysis of a calcareous soil from Gloucestershire :—

Lime	52·33
Magnesia	·31
Oxide of Iron and Alumina	2·86
Phosphoric Acid	Trace
Sulphuric Acid	Trace
Silica	·26
Carbonic Acid	44·70
	100·46

Analysis of Barren and Fertile Sands.

	Barren.	Fertile for Lucerne, Sainfoin, and Lupins.	Fertile for Beans and Peas.
Silica	96·000	94·700	90·220
Alumina	·500	1·600	2·106
Oxides of Iron	2·000	2·000	3·951
Lime	·001	1·000	·530
Magnesia	Trace	Trace	·730
Potash	Trace	·100	·076
Soda	Trace		
Phosphoric Acid	Trace	Trace	·367
Sulphuric Acid	Trace	Trace	Trace
Oxide of Manganese	None	None	·960
Chlorine	None	None	·010
Organic Matter	1·499	·500	1·040
	100·000	99·900	99·990

The above analyses of sandy soils are instructive. The first, that of the barren sand, contains, besides insoluble matter, only ½ per cent. of alumina, a quantity quite insufficient to have any mechanical influence; 2 per cent. of iron, probably as peroxide; 1½ per cent. of humus, and only traces of the most important substances. The second soil is designated as sandy loam, said to produce luxuriant crops of lucerne, sainfoin, and lupins; facts which the chemist could hardly have anticipated, as it only differs from No. 1 in containing 1 per cent. of lime and 1 per cent. more alumina, and a small portion of alkalies. The third analysis is of a soil growing fine pulse crops; and here we have indications of more fertility in the presence of appreciable quantities of phosphoric acid and magnesia, though there is nothing which would lead us to expect the soil anything but poor. These analyses were made by Sprengel, and are not of very recent date, consequently we do not feel such confidence in their accuracy as if conducted on the modern system; indeed little reliance is to be placed upon any old analysis of soils. The fertilising materials are often in such minute quantities, yet sufficient for the requirements of the crop, that they totally escape detection, or can only be represented by a trace; and it may be the variation in the amount of the latter which causes the remarkable difference of fertility in the two first soils. The limit of variation in the best conducted analysis is often equal for some substances (phosphoric acid for example) to the total quantity in the body analysed, consequently in such cases little reliance can be placed on the result. The reagents employed are not always perfectly pure;

the very substances we are looking for may be introduced, and a trace indicated in cases where the soil was quite destitute of it. We are more likely to arrive at correct conclusions as to the deficiencies of soils and the requisite materials to add, by studying the composition of the crops which flourish or will not grow upon them. In the ashes of plants we have a much more concentrated mass to work upon; the soluble portions are not diluted or dispersed, as in the soil, amongst a large mass of insoluble matter, and consequently our analysis, as proved by the similarity of result in different specimens of the same kinds, will be much more worthy of credit.

III.—Effect of Depth of Soil on Vegetation.

The deeper a soil is, or can be made by good tillage, provided it contains the elements of fertility, the more productive it must become, not only by causing a large supply of actual food, but also by presenting an increased surface for the action of chemical forces to retain those valuable substances, which being in solution would otherwise pass away in the subsoil, where, though they might be retained, the roots could not get at them. The atmosphere penetrates more freely, warming and exciting the whole mass; the roots instead of merely throwing out laterally, and creeping along just beneath the surface, as in shallow soils, push boldly out in all directions in search of food, and thus strengthen the plant. It is our belief that the wheat crop requires a deeper soil than is generally thought necessary, and that root-fall is often due to the lateral direction into which the roots are forced by the impassable pan a few inches beneath the surface; at the same time the surface should be made as firm as possible, for there is no doubt that the wheat crop likes a firm, though not a shallow bed. How often we see cases of surface-rooted trees, such as lime or beech, being blown up by the wind, roots and all, while the deep-rooted oak stands firm! The great use of the modern cultivators, so generally employed in fallowing operations, is to stir and lighten up those portions which, too deep to be reached by the plough, are yet pressed down by its weight passing over them. The alluvial tracts so frequently found surrounding our principal rivers, are all deep and very fertile; though generally dry, they never suffer from drought, owing to their powers of absorption, both from the air and subsoil. Depth being so important, we should do all in our power to increase it by artificial means when required; as frequent ploughing at a uniform depth produces even in the deepest soils a hard bed, through which neither roots, air, nor moisture can readily penetrate, the use of the subsoil plough, once in each

rotation, generally after the first ploughing of the stubbles for the fallow crop, is strongly recommended. Where the subsoil consists of a stiff yellow clay, care must be taken not to bring up too much at once ; for else, being of a poisonous nature, it would injure the land for some time, until in fact the oxygen of the air had effected the necessary chemical changes, and sweetened the mass. Deep soils are much less injured by sudden changes of weather than shallow ones, for being open and friable, the rain-fall passes slowly through them, and after nourishing vegetation disappears in the subsoil ; and during a dry time they maintain their moisture, owing to their powers of absorption and capillary attraction. Many of the most fertile loams, resting upon a gravelly and very porous subsoil, owe their fertility to their depth. The same rule holds good with soils resting on chalk or limestone ; they are rich or poor according to depth. Therefore it is evident that in farming, besides the mere routine of preparing the ground for the crop, we have the important business of deepening the soil to attend to. Draining, in all cases where the land requires it, will be found a most important assistant, lowering the water level to the bottom of the drains, some 3 or 4 feet from the surface, enabling the atmosphere, that great fertilizer, to penetrate into the crevices formerly filled with moisture, and by diminishing the tenacity, lessening the difficulties of deep cultivation.

In cases where porous soils rest upon stiff subsoils, occasional subsoiling, by bringing to the surface much valuable matter, which had passed through, will be found equal to a dressing of manure. In the case of clay soils, we are often enabled by deep cultivation to insure a supply of those mineral substances so essential to vegetation, but which are naturally in an insoluble state ; requiring the action of the air and rain water to reduce them to an available condition for the wants of plants. The only caution required, as was before mentioned, is to avoid bringing up more of the sour subsoil at a time than the winter's frost and rains can fertilize, and always to plough deepest in autumn for the fallow crop ; for the frequent stirrings and mixings, which the soil receives for the fallow, whether bare or green, will tend to fertilize, and prevent any injurious effects which might otherwise follow. The way in which the stubbles are managed on a clay farm is a good criterion of the ignorance and poverty, or the intelligence and capital, of the occupier ; if horses are short, they are left untouched till spring, and all the benefits of winter frost, &c., lost ; indeed I have met with men who professed to agree with such a system, and argued against the autumn ploughing as being injurious to the land. It is possible that, in a peculiarly wet season, we should do more harm than good by attempting to

plough; but such cases will be found very rare, and the intelligent man who understands the value of his winter ploughing, will generally find his opportunity. Then again, the slovenly manner in which the work is often hurried over, "because it is only the stubbles and does not matter," is a proof of the ignorance of principles which exists among many so-called practical men. The autumn ploughing of stubbles for the fallow crop is the most important operation of the whole rotation, and the succeeding crops will greatly depend upon the way in which it is done. We should aim at quality rather than quantity, ploughing as deep as the soil will allow, without bringing up above an inch or two of the subsoil; holding small furrows and laying them up at a considerable angle, so that rain will not remain long on the surface; laying out the field into convenient sized lands, higher or lower, larger or smaller, according to the tenacity of the soil; carefully crumbing out the furrows, and making proper grips to carry off the excess of water consequent on heavy winter rains. By such means we insure the soil receiving all the benefits which the changes of weather can produce: the atmosphere will penetrate, because we have taken precautions to allow of the moisture getting away; the soil must become pulverized, and will be ready to work in the spring much sooner than land untouched, which, lying flatter and with no surface drainage, will most likely have remained saturated with moisture all winter, and will turn up raw and stubborn, at the very time that the autumn-ploughed may be ready to receive a crop.* The practice of deep ploughing is happily on the increase, and its importance seems now generally recognised by all the best farmers; yet it is lamentable to see with what fatal attachment a large class still adhere to old customs and prejudices. The practice of Mr. Smith of Lois Weedon, though not of a nature to be followed on the large scale, has been of extreme value in pointing out the immense advantage of deep cultivation on all soils containing any considerable quantity of clay. It seems only extraordinary that in these days of cheap publications and railway communication, it should be necessary to point out and reiterate facts which appear so self-evident to every candid observer. Depth of soil ought to be one of the desideratums of the farmer, and yet with

* Mr. E. Wortley, of Ridlington, W. Uppingham, Rutland, a most intelligent agriculturist, has adopted a rather novel mode of treating his fallows. The stubbles are carefully forked after harvest, and the land laid up in ridges, the plough being set about 8 inches deep; by this means a great extent of surface is exposed to atmospheric influences. As opportunity offers, the intervening spaces are subsoiled. Early in Spring the ridges are split, the soil being, of course, thrown back upon the subsoiled ground, and left in this state until the root-crop is sown. The soil is stiff clay, and, having lately examined the land, I can testify to the beautiful mould-like state it is in.

the means so frequently in his own hands, he ridicules the idea of making use of them.

IV.—Warmth or Coldness of Soils.

The temperature of a soil is a most important condition, since vegetation is increased, checked, or actually retarded, according to the warmth or coldness of the soil: to be convinced of this we have only to compare crops growing on wet undrained clay, which we find starved in appearance and yielding a wretchedly small produce, with the luxuriant dark-coloured shoots made in a dry, well-cultivated soil. Warmth is dependent upon dryness, porosity, and colour. Clay soils are cool, even when well drained and cultivated; in a natural state they are very cold. This is due to their cohesive property keeping them moist, preventing the sun's rays from penetrating, and the evaporation constantly going on from their surface. It has been proved that water evaporated from the soil extracts for the same volume an equal amount of heat as when converted over a fire into steam. When we remember that it requires six times as much heat to convert a pound of water into steam as to raise the same from 50° to the boiling point, we can form some idea of the coldness of a soil constantly full of moisture. Water possesses little or no conducting power, and therefore keeps a soil cold by preventing the heat descending: it also radiates heat more rapidly than the soil itself, and, owing to its peculiar laws of density, may farther reduce temperature by changing places with the warmer water below, until the whole mass is reduced to 42°. By draining we entirely alter all this, converting the water into a carrier of heat. The rain-water, often warmer than the soil, especially in winter, instead of evaporating from the surface, passes slowly downwards, supplying the wants of vegetation and increasing the temperature by giving up a portion of its own heat to the surrounding soil. If the rain is cooler than the soil, which is generally the case in summer, it abstracts heat from the surface, giving it up again to the subsoil, and thus equalising the temperature of the whole mass. The experiments of Mr. Parkes, already detailed in a former number of the Journal, are very valuable, as showing the important part free circulation of water plays in regulating the temperature of the soil. For the benefit of those who may not have the opportunity of studying his valuable paper (vol. v., p. 119), I may be pardoned for briefly alluding to them. The site chosen was a peat-bog in Lancashire, his object to determine the temperature of both surface and substratum in the natural semifluid state, and after drainage and cultivation. His observations were conducted by means of ther-

mometers placed in the soil at various depths. In the natural peat, the depth of which was 30 feet, he found that during the whole time of his experiments (nearly three years), with only one exception, the temperature from 12 inches below the surface to the bottom of the bog was uniformly 46°. The exception took place during the winter of 1836, when the thermometer nearest the surface fell for a few days to 44°. Into the cultivated portion, which had been thoroughly drained, ploughed, and dug deeply, five thermometers were inserted at the following depths—7, 13, 19, 25, and 31 inches. The experiment only extended over 12 days, the examination being made twice a-day, at 9 A.M. and 2 P.M.; the result was a very different temperature for each depth, greatest and most variable at the surface, least and most regular at the greatest depth, where the temperature only varied during the whole time from 46° to 48°; while that at 7 inches varied from 52° to 66°, was always highest at 2 P.M., and appeared to vary according to the temperature of the air. The second bulb, 13 inches from the surface, ranged from 50° to 57°; the third, at 19 inches, 48·4° to 52·8°; and the fourth, at 25 inches, from 47° to 50·2°. These experiments speak for themselves, and will afford a ready explanation of the otherwise marvellous effects which often follow thorough drainage. The increase and variety of temperature could alone be due to the removal of excess of water, and consequent permeating influence of rain-fall, atmosphere, and sun's rays.

Loamy soils and sands are warm, from their dryness, porosity, and colour. Chalks and limestones are cooler, their light colour rendering them bad absorbents and good reflectors. All soils radiate the heat received from the sun's rays back again into the atmosphere as soon as the latter cools down to a lower temperature, but in different degrees depending upon the state of mechanical division, colour, &c.; that soil ought to be warmest which absorbs most readily and radiates most slowly, and this is the case with sands. The formation of dew is connected with this radiating power; the soil, giving up its heat, becomes cold, and lowers the temperature of the stratum of air immediately above it, causing a portion of the moisture which it contained in a state of vapour to be deposited as dew. But this very deposit of dew, being a conversion of steam or vapour back into water, is attended with the liberation of considerable heat, which probably helps to make up for the loss by radiation. We only see dew after still, clear nights, because the clouds radiate back and so keep up the temperature of the soil, and wind acts in the same way.

We can easily test the relative powers of different soils to retain heat by subjecting portions to a strong heat, noting how soon they lose it again. Sand by such means has been found to retain heat for the longest period; clays stand at about 65 to 70

in comparison to sand at 100; humus only at 49: this power appears to bear a close relation to the weight of a soil. The power of becoming warmed by the sun's rays, which is another cause of the temperature of soils, appears to depend upon colour and dryness; the darker the soil is, the greater its power of absorbing heat.

Thoroughly dry soils, whatever their colour or nature, though varying in temperature are never cold. Moisture being the principal cause of low temperature, we often have the remedy in our own power; thorough drainage, by diverting the water that previously clogged up the pores of the soil, and was continually evaporating from the surface, into new channels by which it is carried directly to the ocean, not only warms and invigorates the particular case, but assists in improving the general climate of a district, by rendering it drier, and removes the seeds of those rheumatic diseases so prevalent and fatal in former times.

V.—Suitableness of different Soils to different Crops.

In these days of high farming, when the extraordinary powers of artificial stimulants enable us to grow almost any description of crop on every variety of soil, we are somewhat in danger of forgetting that certain soils are adapted to the growth of peculiar descriptions of plants; and that we shall act most wisely by so arranging our rotation as to repeat most frequently those crops which practical experience as well as chemical knowledge tell us are the natural produce of such soils. There is at the same time no doubt that, as knowledge increases and practice improves, less stress will be laid upon the importance of adhering to particular rotations, and we shall be enabled to grow more frequently those crops which prove most remunerating. Just as laws were made for rogues, rotations are found necessary as a check to bad farming, and are evidently only adapted to an imperfect condition of agriculture. As our knowledge of the laws and principles of vegetable economy becomes perfected, we shall be able to make those applications of manures required by our crop, and which the soil did not possess in sufficient or available quantity. At present we have not attained this desirable point; and though certain kinds of soil under judicious management may be made to bear the same crop very frequently, the rule holds good that certain crops and certain soils are peculiarly suitable for each other. The natural herbage of a stiff clay, porous sand, or dry chalk soil, will sufficiently prove this fact. All farmers know that the prevailing weed of strong land is the couch grass (triticum repens), the type of wheat, from which it may have originally sprung, for we have no wild variety of wheat as we have of barley and oats; therefore we may consider that clay land is peculiarly

adapted to the growth of wheat. The miserably deficient crops which we too often see on some of the strong land districts (the weald of Kent and Sussex, for instance) is no disproof of this, since it arises from the wetness and poverty of the ground, and would prove even more fatal to other cereals. Of course it would be untrue to say that such soils would grow better crops of wheat than light warm soils in good condition, but they will bear the wheat crop more frequently repeated than other cereals, although the result is often very dismal: but what I would say is, that clay of an average quality, containing a certain portion of silicates and alkalies, freed from excess of moisture, and properly cultivated, is the proper soil for the wheat crop, and in no other can we obtain such large or frequent crops without the aid of extraneous manures. The wheat crop being more remunerative than any other grain, we should expect to find clay soils bringing the highest price in the market; such was the case formerly, when the practice of agriculture was confined within narrower channels, and such would be the case now were there not counter objections, such as the great expense of working, and the unsuitableness of such land for the rearing, &c., of stock. The general adoption of turnip husbandry and the low price of wheat during the last few years have tended to depreciate the value of such soils by giving an undue value to the lighter ones. The writer of this essay is of opinion that we shall see a reaction of public opinion in this respect, and that under the influence of thorough drainage and enlightened practices, clay soils must attain a much higher comparative value than is the case at the present time. Once open the soil and allow the atmosphere thoroughly to penetrate, and the great objections will be removed: the expense of cultivation need not then greatly exceed light land; the growth of the root crop and its consumption on the land will become practicable; the farmer may look for profit to his stock as well as his crop, to the fold and the barn-door. On a good soil it is quite possible to get three wheat crops and one bean crop without exhausting the land in a six years' rotation, commencing with 1 fallow, 2 wheat, 3 spring beans, 4 wheat, 5 seeds, 6 wheat.

Another desirable feature in many clay soils is the excellent pasture they produce when properly drained. If we except the small tracts of alluvial soil which border some of our principal rivers, our best feeding land rests on clay. A due admixture of pasture and arable land is invaluable to the cold-land farmer; the consumption of the straw with cake in the yards during winter supplies abundant manure for the ploughed ground. The flock must be maintained either on the grass with roots, or, weather permitting, penned on the land. During summer and autumn, when the light-land farmer has most difficulty in finding

a scanty living for his flock, the clay farmer is filling his pockets with the produce of his fat stock, turned out of his pastures often without the aid of corn, and not unfrequently tumbling over, that is, selling for double what they cost the previous winter. From these considerations we trust it will appear that the cultivation of good strong land often offers the most favourable investment for capital; and that as more liberal ideas and sounder principles of agricultural economy become general, the value of such land will be considerably increased. Clay land requires more capital to stock and work it than lighter soils, and this will prove an objection to those who pride themselves upon the number rather than the quality of their acres; but we must hope that this absurd vanity is fast giving place to more rational ideas.

The oat crop will often grow well on heavy land, and is not unfrequently taken after the wheat crop—a system which science condemns, but practice often finds remunerative. Still it is an uncertain crop, depending much more upon season than wheat. It seems to like a soil containing large quantities of vegetable matter in a state of decomposition, combined with a sufficient amount of mineral ingredients; consequently it is almost always the first crop grown on new land, often put in as soon as the sod is turned. It is, however, better practice to fallow the land first, liming, and sowing potatoes, rape, or turnips, feeding the latter off, and thus consolidating the surface; then drilling in the oats, keeping the land as firm as possible. The oat crop requires less mineral matter than the wheat; the straw is more flaggy and less strong, and contains a larger proportion of organic matter. This is perhaps the reason why it succeeds where wheat would almost certainly fail. The wheat crop requires more silica, phosphoric acid, and alkalies than either oats or barley, and this may in some measure explain its particular habitat.

Barley grows well on calcareous and loamy soils, but is uncertain and of a coarse quality on clay land. Formerly it was thought almost impossible to grow it on stiff soils; but the effects of deep drainage have dispelled this fallacy, and in many cases very bulky crops of indifferent quality have been obtained. Still, when the land is good enough for wheat, it will not be often taken, as it is less remunerative, and appears to injure the next wheat crop by loosening the soil too much. Barley likes a dry porous soil, and is well adapted for sandy and light calcareous soils following the root crop consumed on the land. Beans require a deep, strong, and yet dry soil, containing a certain portion of lime: the soils on many of the oolite beds are well adapted to grow this crop. Many people consider it an exhausting crop, and of course, inasmuch as it is a grain crop, it takes a good deal out of the land; but the roots run down when the soil is open and feed on the

subsoil, and thus do not exhaust so much as might be expected. Beans are generally drilled much too close together, so as to prevent the frequent hoeings, which would prove of such advantage to the land. Peas resemble beans in their partiality for soils containing lime, but prefer a less retentive soil, and do not require it so deep. Lime seems the great necessary for the pea crop, and if we neither have it naturally nor add it, we must not expect a crop. The other cultivated members of the leguminosæ, such as clovers, lucerne, vetches, sainfoin, &c., all flourish best on calcareous soils; indeed some of them, the sainfoin for instance, will only grow on such soils; the others receive great benefit by the addition of lime when grown in soils deficient in it. Top dressings of gypsum (sulphate of lime) on clover leys in spring are found to have the most marked effect where the soil is sandy. The gypsum should be sown in early morning, when the leaves are covered with dew; the fine powder, in which form it is best applied, adheres to the leaf, and is no doubt gradually carried down into the soil. About 2 to 3 cwt. per acre is a sufficient dressing, and as the price is almost nominal, its application in such cases should never be neglected. The ashes of leguminous plants, as we should expect, exhibit a large percentage of lime: thus in beans 100 parts of the ashes of the whole plant contain about 35 per cent. of lime; peas a less quantity, from 6 to 10 per cent., with large quantities of potash and soda; sainfoin about 26 per cent.; and red clover from 25 to 30 per cent. These analyses very clearly indicate the reason why leguminous plants prefer calcareous soils, and they also point out the necessity for applying small doses of lime simply as a manuring substance to all soils where it is deficient. Peaty soils are not generally adapted to the growth of corn crops, because of the excess of organic and deficiency of mineral matters, and their open nature preventing the roots getting a firm hold and supporting the plant. Oats will grow best of any corn crop; but they are uncertain, especially as a first crop, too often becoming flaggy in straw, owing to the absorption of too much organic matter, and falling before ripe. Root crops succeed better, requiring a large quantity of such food and a very small portion of mineral matter. The composition of the turnip, as given by Voelcker, shows this: in 100 parts he finds—

Of Water	90·43
Sugar, Gum, &c.	4·69
Albuminous Compounds	1·14
Vegetable Fibre	3·10
Mineral Substances	·62
	99·98

Root crops living so much by their leaves, and taking such small quantities of the valuable mineral matters out of the soil, will grow on every variety of land, provided we can once ensure a good start for the young plant, and the soil be sufficiently open to allow of the swelling of the bulb. There is, of course, a wide difference in the relative amount of crop which different soils will produce without manure; but the intelligent cultivator can remedy any defect by the application of small doses of forcing manures, added to thorough and frequent stirring of the soil—a point which seems as necessary to healthy growth as the presence of the manure itself. The successful cultivation of the turnip and other root crops depends upon climate more than upon soil, and therefore we can hardly name any peculiar soil as specially adapted in all cases to grow these crops. We may safely say that stiff undrained clay is not suitable, but ought speedily to be made so, and that all other descriptions of soils, where climate is favourable, will, under judicious management, produce a green crop.

Mangold wurtzel seems adapted for growing on soils too stiff for the white turnip, or swede; and as it possesses valuable feeding properties, and will usually grow a greater weight, we strongly recommend its more general adoption. It will be found invaluable for stock late in the spring, when the rawness, so evident before Christmas, will be replaced by a large percentage of saccharine matter; indeed so rich do they then become, that great caution is necessary not to give lambing ewes, &c., too many while the lambs are young. Many farmers think it more exhausting than the swede crop. Nothing in its analysis would lead to such a conclusion; on the contrary, we find a large percentage of common salt—a substance that can be added as a top dressing for a mere trifle. Carrots and parsnips require deep sandy soils where no obstructions exist to the descent of the tap roots. Potatoes also thrive best upon light loamy soils, at least they appear less subject to disease in such situations; formerly they were profitably grown on every description of soil.

We may sum up what has been stated above as follows:—Stiff soils are peculiarly adapted to the growth of wheat; when drained, well cultivated, and containing a portion of lime, they grow beans better than any other sort of land, but are not so well adapted to the growth of root crops as lighter soils. Calcareous soils produce good quality of barley, root, and all leguminous crops, while sandy soils are adapted for rye, flax, and roots of all descriptions.

VI.—Necessity or otherwise for the presence of Vegetable Matter in Soils.

That vegetable life is capable of existence in the absence of decayed humus, is proved by the growth of the lowest forms of vegetable life in the crevices of bare rocks. That the decay of these, by adding humus to the disintegrated rock, greatly assisted in the subsequent fertility of the soil, is beyond doubt, and we may conclude that soils would lose much of their fertility from the total absence of vegetable matter, supposing such a thing possible, which it is evident could not be, when we consider the origin and gradual formation of all soils. The dark colour of soils is in general due to the presence of vegetable and animal matter; such soils are always more fertile than white, light red, or brown soils, consequently it is fair to presume that the fertility is due, at least in part, to the presence of vegetable matter. The advantages which follow heavy applications of vegetable manures, such as sea-weeds, &c., are a further confirmation of this. From the fact of vegetable matters existing in all soils, it was supposed in earlier days of scientific investigation that the amount of humus determined the relative value of soils—an erroneous conclusion, as many of the most valuable soils only contain from 2 to 3 per cent., while peats, containing from 80 to 90 per cent., are often quite barren. Humus is decomposed vegetable matter, and its nature and qualities depend upon the circumstances under which the decay was conducted: thus brown peat is usually the result of decay under water, whereas black peat has been formed by free oxidation, and is much more valuable or rather less acid and noxious in quality than brown peat. The researches of some foreign chemists, especially Mulder, have shown that the changes which vegetable matter undergoes in the presence of oxygen are numerous and peculiar, consisting in the formation of a succession of organic acids and the elimination of a portion of carbonic acid, until, if the process be carried out, the last of the series resolves itself into carbonic acid and water. Mulder believed that each of these acids, uniting with lime or alkalies, was suitable food for plants, being decomposed in the cells of the plant, thus affording unlimited supplies of carbonic acid and oxygen. Chemists, however, are now generally agreed that such views are erroneous, and confine the value of peat in the soil to its power of absorbing heat and ammonia, and supplying by gradual decomposition carbonic acid, and possibly small quantities of ammonia or nitric acid; qualities which are undoubtedly of great importance, but which cannot render a soil fertile unless proper mineral matters are present. I believe it is not at all certain whether ammonia is produced during the changes which

humus undergoes. It has been thought possible that the nitrogen of the atmosphere may, under certain circumstances, unite with the nascent hydrogen, set free from combination with carbon and oxygen. The following analyses of fertile and barren peats are taken from the article on Soils, in 'Blackie's Encyclopædia,' and are by Mulder and Sprengel :—

	Mulder.		Sprengel.			
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Organic Matter and Combined Water	12·000	12·502	10·90	16·70	37·00	90·44
Potash	1·026	1·430 }	·01	·06	Trace	·01
Soda	1·972	2·069 }				
Ammonia	·060	·078	..	..	Trace	Trace
Lime	4·092	5·096	1·00	·13	·32	·55
Magnesia	·130	·140	·20	·03	·31	·08
Peroxide of Iron	9·039	10·305 }	6·30	·64	·52	·12
Protoxide of Iron	·350	·563 }				
Protoxide of Manganese ..	·288	·354	..	..	..	..
Alumina	1·364	2·576	9·30	·78	·45	·63
Phosphoric Acid	·466	·324	·13	·11	Trace	·02
Sulphuric Acid	·896	1·104	·17	·02	Trace	·19
Carbonic Acid	6·085	6·940	..	..	..	..
Chlorine	1·240	1·382	Trace	·01	Trace	Trace
Soluble Silica	2·340	2·496 }	71·80	81·50	61·57	7·96
Insoluble Silica (Clay) ..	57·646	51·706 }				
Loss	1·006	·935	·19	·02	..	..
	100·000	100·000	100·00	100·00	100·17	100·00

Nos. 1 and 2.—Fertile soils of a tract of land in North Holland, gained by embankment from the sea.

No. 3.—Rich vegetable mould, near Wager, in Germany, flooded by the river.

No. 4.—Poor sandy mould, near Brunswick.

No. 5.—Very infertile, peaty soil, near Aurich, in East Friesland.

No. 6.—Boggy, sterile lands, near Giffhorn, in Germany.

We hardly require reference to the foot-notes. A glance at the relative proportions of those mineral matters which have been spoken of as necessary to vegetation would at once point out the fertile from the barren soils. The analysis appeared worthy of insertion, as bearing out what was stated above, that the presence of vegetable matter alone cannot ensure fertility. The three last soils would all be capable of great improvement by the addition of large doses of lime, calcareous gravel, or marl; and in cases where such soils rest upon or lie adjacent to a calcareous substratum, such mixtures will be practical, and prove in the end very remunerative. The presence of a small percentage of vegetable matter seems requisite to ensure a fertile soil, and for general cultivation is perhaps better than a larger proportion, since cereal crops generally do not flourish in the latter case, probably owing

to the absorption of too much carbon in proportion to silica, making the straw soft and flaggy and unable to bear the ripening ear. Peat bogs that have been reclaimed by draining and marling are found better adapted for pasture than arable farming; the most approved method of management being to cultivate for the first few years till the humus is thoroughly decomposed, and then lay down with permanent grasses, the feeding of which firms the land and in time produces a valuable herbage. In most soils we find a deficiency of vegetable matters, and the farmer is anxious to supply as much as possible, in the form of farm-yard manure, sea-weeds, and decayed rubbish of all sorts; such manures act as direct food and mechanically in keeping the soil open. We should strongly advocate the occasional application of small dressings of lime between the manurings, because it would come into contact with undecomposed portions of manure—humus in fact which otherwise might lie dormant in the soil—causing the formation of a further supply of carbonic acid for the roots of plants.

In concluding this paper the writer feels it necessary to apologise for the scanty and imperfect information he has been able to produce on several points, and to crave the indulgence of the reader generally in consideration of the difficulties with which this subject abounds. The patient and oft-repeated experiments of the scientific investigator, added to a careful record of facts by the practical cultivator, will in course of time add much to our present meagre knowledge of the real causes of barrenness and fertility in soils.

Deene, Northamptonshire.

XII.—*Report to the Right Honourable the Earl of Leicester—on Experiments conducted by Mr. Keary on the Growth of Wheat upon the same land for four successive years, at Holkham Park Farm.* By J. B. Lawes, F.R.S.

It has been proved by careful experiments that wheat can be grown for several years in succession upon "heavy" land, and that by means of a proper supply of certain chemical substances, an average or even full agricultural crop, according to the season, may be obtained each year with certainty. But it is believed that there have been no experiments of the same kind carried on with accuracy and on a large scale, upon soils other than those of a comparatively heavy character. It is, indeed, not many years since the practice of removing from any land more than one

corn crop in succession, was condemned as bad in principle; and when we consider what was the amount of produce generally obtained in the second year, it must be admitted that, under the circumstances then existing, the practice could not be easily justified. The increased sources, however, of artificial manures which have of late years been opened up, and more especially the comparatively large and cheap supplies of that valuable agent ammonia, have furnished the agriculturist of the present day with a means of increasing, and in many cases of repeating, his corn crops, which was not possessed by his predecessor. To those heavy lands on which root crops were considered but as a necessary evil, these comparatively cheap and abundant sources of ammonia may be considered almost as great a boon as the application of the four-course system to the light soils by the late Earl of Leicester. The limit, however, up to which the growth of corn by means of artificial manures may safely be extended on different descriptions of soil, has yet to be fixed by the aid either of practical experience, or of more direct experiment.

Leaving out of the question for the moment the important influence of the subsoil in modifying the character and fertility of different descriptions of land, it may be said that, whilst in the "*heavy*" soil certain elements of fertility are comparatively more inexhaustible, though capable of liberation in but small quantities each year,—in the "*light*" soil, on the other hand, there is generally a less store of the elements of fertility, though they will yield up more rapidly those which are added to them in the form of manure. There is, however, an almost infinite variety in the characters of our soils; in some parts of our island we have those of the most opposite description within a short distance of each other; and there are some which so combine the qualities of "light" and "heavy" land, as to render it difficult on which side to classify them. There are others, again, which are decidedly light in character so far as the surface soil is concerned, but which possess in their subsoil a vast storehouse of some of the native elements of fertility; and hence whilst they are amenable to the same mechanical and other general management of the so-called light soils, they are more nearly allied to the heavy soils so far as the *native resource* of fertility is concerned. Whilst, then, a broad distinction must always exist between soils which can without injury be trodden by sheep in the wettest weather and those which under the same circumstances will scarcely bear a foot to be put upon them—and it may be convenient to apply to them the current designations of "*light*" or "*heavy*" accordingly—it must at the same time be remembered that these terms, as applied to a *surface-soil*, afford a very imperfect indication of the probable native resources, and

consequently of the capabilities of growth without deterioration of the respective soils.

The soil upon which the experiments now to be recorded were made, is described by Mr. Keary as a "light, thin, and rather shallow brown sand loam," but "resting upon an excellent marl which contains a large quantity of calcareous matter." And he adds that he has invariably found these light sand loams *with the above subsoil* "to be most productive and grateful for *high farming.*" In such a surface-soil, then, there will be combined the easily working qualities and the power of rapidly yielding up manurial matter of the so-called "light" soils; whilst in its subsoil, we have much of the native resource of constituents and probably the power of absorption or retention of manurial matter also, of the so-called heavy soils. Still it is of the greatest interest, both in a scientific and in a practical point of view, to ascertain by actual experiment how far those chemical substances which are employed with success for the increased growth of wheat upon heavy soils, can be used with advantage upon those of different descriptions: and these experiments are therefore of considerable value towards filling up one gap in our knowledge on this subject.

Here it may be suggested, that one very great desideratum at the present time is a few carefully-conducted experiments, not on too small a scale, to ascertain the result of the successive growth of wheat, on different descriptions of land, both unmanured and with a few well-selected artificial manures. How comparatively trifling would be the cost and trouble if one person only in each agricultural district in Great Britain would devote three acres of land in half-acre plots to the continuous growth of wheat for a series of years; one portion being always unmanured, one manured with farmyard dung, one with mineral manures only, one with ammoniacal salts only, one with both the minerals and the ammoniacal salts, and another with rape-cake? Yet such a simple series as this, carefully performed and accurately recorded, would in a few years furnish us with results which would be invaluable both in elucidating agricultural practices as they are, and in affording a sound basis for deduction, with a view to improvement according to the variations of soil and climate.

It may be well to mention, that with the exception of a suggestion as to the nature and amount of the manures to be applied, and the supplying of some of them from the quantities prepared for the Rothamsted experiments, these experiments at Holkham have been entirely under the management of Mr. Keary. That they have been conducted with extreme care and accuracy is, however, to those accustomed to make agricultural experiments

upon a large scale, as obvious from the results recorded as if each operation had been witnessed. With a certain degree of experience it is impossible to be deceived in such matters; and it may safely be stated that it is the injudicious arrangement, the careless performance, and the inaccurate record of agricultural experiments, that more than anything else retard our progress in scientific agriculture at the present time.

It should further be remarked with regard to the land upon which these experiments were made, that previous to the introduction of the four-course system by the late Earl of Leicester, it had been considered too light for the growth of wheat. It has now for some years been farmed under that system; it was clayed about 12 years prior to these experiments, and the crop immediately preceding them was white turnips, manured with farmyard dung and guano, both tops and bulbs being drawn off the land. The experimental plots were half an acre each; the manures were as follows, and were all sown in the autumn, except No. 4, which was sown in spring:—

No. 1. Always unmanured.
No. 2. Mineral manures alone.
No. 3. Ammonia-salts alone; sown in the autumn.
No. 4. Ammonia-salts alone; sown in the spring.
No. 5. Both the mineral manure and ammonia-salts.
No. 6. Rape-cake.
No. 7. Farmyard dung.

The quantities per acre of the different manures are given in the Tables of the results which follow.

The *unmanured plot*, when once exhausted of the accumulations derived from the more recent previous manuring, will, of course, show the productive capability of the soil in a comparatively normal state, in conjunction with that of the annual climatic yield of the atmospheric elements of growth; and the results will provide a standard with which to compare the produce of the different manures.

The *mineral manure* employed, provides a liberal supply of the alkalies, alkaline earths, and phosphoric acid; and the produce it yields compared with that of the other plots, shows whether the result of the cropping is to reduce the available supplies of such mineral constituents in the soil below that which is requisite to obtain the full benefit of the annual atmospheric supply of carbon and nitrogen, or whether it is the supply in the soil of the carbon or the nitrogen which is most exhausted.

The use of *ammoniacal-salts alone*, which provide *nitrogen* for the growth of the crop, shows whether or not the latent mineral

wealth of the soil is more than sufficient for the annual atmospheric supply of available nitrogen. And the object of sowing one plot with ammoniacal salts in the autumn and another in the spring, was to show whether it was practically advantageous to sow such soluble manures in the autumn in so light a soil.

The mixture of *both the minerals and the ammoniacal salts* shows, when the results are compared with those of each of these manures used separately—1st, whether or not the annually available native mineral supply of the soil, taken together with that in the manure, was not competent to a much greater amount of growth than the annual atmospheric supply of nitrogen was sufficient to produce?—and 2ndly, whether the amount of nitrogen supplied to the soil, when such a quantity of ammoniacal salts was used alone, was not in excess in proportion to the annually available supply of minerals from the soil itself?

Rape-cake contains a large proportion of carbonaceous and nitrogenous organic substances, and some mineral matter; and the nitrogen which was supplied in the quantity of it used was nearly identically the same, or perhaps rather greater in amount, than that in the ammoniacal salts of the other experiments.

The *farm-yard dung* employed, was the product of yards in which bullocks were fed on turnips, with a moderate quantity of oilcake. In this farm-yard dung, there would be added to the soil every year a larger supply of every constituent than was contained in the increased wheat crop grown.

In the three following Tables are given, the quantities of the different ingredients used as manure, and also the results obtained.

In Table I. are given—The amounts per acre each year on each plot, of the dressed corn, the offal corn, and the straw.*

In Table II. are given—The total produce of corn for the four years collectively, and of the straw for the last three years, of each plot; the average annual produce, both including and excluding the first year of the experiment; the total increase by manure of corn in the four years, and of straw in three years; the average annual increase by manure; and in the last column, the amount of corn yielded by each plot in the first year (1851) above the average of the succeeding years.

In Table III. are given—The weight per bushel of the dressed corn of each plot each year, and the average of the four years; also the proportion of offal corn to 100 dressed corn in each case; and the proportion of corn to 100 parts of straw.

* It is much to be regretted that *the straw* was only weighed in the three last years, and that in no case is the weight of chaff and "colder" or "cavings" given.

Table I.

Showing the Quantities of Dressed Corn, of Offal Corn, and of Straw, per Acre, on each Plot in each Year.

No. of Experiment.	Manures per Acre per Annum.		Dressed Corn per Acre.								Offal Corn per Acre.								Straw per Acre.		
	Description.	Quantity.	1851.		1852.		1853.		1854.		1851.		1852.		1853.		1854.		1852.	1853.	1854.
		lbs.	bus.	pks.	bus.	pks.	bus.	pks.	bus.	pks.	bus.	pks.	bus.	pks.	bus.	pks.	bus.	pks.	lbs.	lbs.	lbs.
1	Unmanured	..	39	2¼	15	2½	21	2	16	3⅛	0	3½	0	0½	0	0½	0	0¼	964	1690	1240
2	Sulphate of Potash " Soda " Magnesia Super-phosphate of Lime { Calcined Bone-dust Super-phosphate of Lime { Sulphuric Acid	300 200 100 200 150	34	2	19	0½	19	3	18	2¼	0	3½	0	0¼	0	1	0	1¼	1542	1984	1574
3	Sulphate of Ammonia Muriate of Ammonia	200 200	44	0	30	3	27	1	23	2½	1	2½	0	0½	0	1	0	1¼	2276	2312	2132
4	Sulphate of Ammonia Muriate of Ammonia	200 200	41	0⅛	28	0	31	2	23	1¼	1	1	0	0½	0	1	0	1½	2176	2760	1792
5	Sulphate of Potash " Soda " Magnesia Super-phosphate of Lime { Calcined Bone-dust Super-phosphate of Lime { Sulphuric Acid Sulphate of Ammonia Muriate of Ammonia	300 200 100 200 150 200 200	47	1	31	2½	29	3½	36	1½	1	0	0	0½	0	1	0	2	2410	2798	3307
6	Rape-cake	2000	52	0	33	1½	30	3	31	1	1	3½	0	1	0	0½	0	1	2598	2786	2856
7	Farmyard Dung	14 tons.	43	3½	31	0	30	2½	30	0	1	0	0	1	0	1	0	0	2430	2790	2599

TABLE II.

Showing the Total Produce of Corn for the Four years collectively, and of the Straw for the last Three years; the Average Annual Produce, both including and excluding the First year of the experiment; the Total Increase by Manure; the Average Annual Increase by Manure; and the amount of Corn yielded by each Plot in the First year (1851) above the Average of the succeeding years.

No. of Experiment.	Manures per Acre per Annum.		Total Produce of 4 years' Corn and of 3 years' Straw.			Average Annual Produce of			Average Annual Produce of 1852-4.			Total increase by Manure (Corn 4 years, Straw 3 years).			Average Annual Increase by Manure.			Total Corn in 1851 above the Average of ditto in 1852-4.
	Description.	Quantities.	Dressed Corn, 1851-4.	Offal Corn, 1851-4.	Straw, 1852-4.	Dressed Corn, 1851-4.	Offal Corn, 1851-4.	Straw, 1852-4.	Dressed Corn.	Offal Corn.	Straw.	Dressed Corn, 1851-4.	Offal Corn, 1851-4.	Straw, 1852-4.	Dressed Corn, 1851-4.	Offal Corn, 1851-4.	Straw, 1852-4.	
		lbs.	bus. pks	bus. pks	lbs.	bus. pks	bus. pks	lbs.	bus. pks	bus. pks	lbs.	bus. pks	bus. pks	lbs.	bus. pks	bus. pks	lbs.	bus. pks
1	Unmanured	..	93 1⅞	1 1¼	3894	23 1½	0 1¼	1298	17 3¼	0 0½	1298	–	–	–	–	–	–	22 1¼
2	Sulphate of Potash . . . ,, Soda . . . ,, Magnesia . . Super-Phosphate of Lime { Calcined Bone-dust Sulphuric Acid . .	300 200 100 200 150	91 3¾	1 2	5100	23 0	0 1½	1700	19 0½	0 0¼	1700	1 2⅛	0 0¾	1206	0 1½	0 0⅜	402	16 0½
3	Sulphate of Ammonia . . Muriate of Ammonia . .	200 200	125 2½	2 1¼	6720	31 1⅜	0 2¼	2240	27 0¾	0 1	2240	32 0⅝	1 0	2826	8 0⅛	0 1	942	18 0¼
4	Sulphate of Ammonia . . Muriate of Ammonia . .	200 200	123 3⅜	2 0	6728	31 0	0 2	2243	27 2½	0 1	2243	30 1½	0 2¾	2834	7 2⅜	0 0¾	945	14 1⅜
5	Sulphate of Potash . . . ,, Soda . . . . ,, Magnesia . . Super Phosphate of Lime { Calcined Bone-dust Sulphuric Acid . . Sulphate of Ammonia . . Muriate of Ammonia . .	300 200 100 200 150 200 200	145 0½	1 3½	8515	36 1⅛	0 1⅞	2838	32 2½	0 1¼	2838	51 2⅝	0 2¼	4621	12 3⅜	0 0½	1540	15 1¼
6	Rape-cake	2000	147 1½	2 2	8240	36 3⅜	0 2½	2747	31 3¼	0 0¼	2747	53 3⅝	1 0¾	4346	13 1⅞	0 1¼	1449	21 3½
7	Farm-yard dung	14 tons.	135 2	1 2	7819	33 3½	0 1½	2606	30 2¼	0 0¾	2606	42 0⅛	0 0¾	3925	10 2	0 0⅜	1308	14 0¼

TABLE III.

Showing the Weight per Bushel of Dressed Corn; the Proportion of Offal Corn to the Dressed as 100; and the Proportion of Corn to Straw as 100.*

No. of Experiment.	Manures per Acre per Annum.		Weight per Bushel of Dressed Corn.					Proportion of Offal Corn to Dressed as 100.					Proportion of Total Corn to Straw as 100.*			
	Description.	Quantity.	1851.	1852.	1853.	1854.	Average.	1851.	1852.	1853.	1854.	Average.	1852.	1853.	1854.	Average.
		lbs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.									
1	Unmanured	..	63 14	59 12	62 0	62 0	61 14	2·21	0·80	0·58	1·12	1·40	97·6	79·3	86·2	86·0
2	Sulphate of Potash	300														
	,, Soda	200														
	,, Magnesia	100	63 10	59 12	63 0	63 8	62 7	2·54	0·33	1·26	1·68	1·63	74·3	63·5	76·1	70·7
	Super-phosphate of Lime { Calcined Bone-dust	200														
	Super-phosphate of Lime { Sulphuric Acid	150														
3	Sulphate of Ammonia	200	63 10	59 12	60 8	58 8	60 9	3·69	0·41	0·92	1·32	1·84	81·0	72·0	65·8	73·1
	Muriate of Ammonia	200														
4	Sulphate of Ammonia	200	63 8	58 0	61 0	58 0	60 2	3·00	0·41	0·79	1·61	1·61	75·0	70·2	76·9	73·5
	Muriate of Ammonia	200														
5	Sulphate of Potash	300														
	,, Soda	200														
	,, Magnesia	100														
	Super-phosphate of Lime { Calcined Bone-dust	200	63 10	61 4	63 0	63 0	62 11	2·12	0·39	0·84	1·37	1·29	80·7	67·8	70·2	72·4
	Super-phosphate of Lime { Sulphuric Acid	150														
	Sulphate of Ammonia	200														
	Muriate of Ammonia	200														
6	Rape-cake	2000	63 10	59 12	62 8	62 8	62 1	3·60	0·75	0·41	0·80	1·70	77·3	69·3	68·9	71·7
7	Farmyard Dung	14 tons.	63 8	60 8	63 8	64 0	62 14	2·28	0·81	0·82	0·00	1·11	77·8	70·3	73·9	73·8

* It must be remembered that the "Straw" does not include the Chaff and Colder or Cavings, which partly accounts for the very high proportion of Corn.

It is seen in the Tables that the experiments have already extended over four seasons, namely, 1851-2-3-4. And although, owing to the variable effects of climatic agencies according to the nature of the manurial matters in the soil, and the stage or tendency of growth of the plant depending on it, and to the little that has yet been accomplished towards reducing the results of these complex influences within the rule and measure of calculation, it is highly important that such experiments should be conducted through a considerable series of years, so as to get a fair average, and thus to exclude the influence both of recent accumulations in the soil, and of the climate of individual seasons—nevertheless, the results of these first four seasons are of very considerable interest. And they can hardly fail to afford further proof to the practical farmer as to what are the constituents which, in the general course of agriculture with rotation and home manuring, and especially with a liberal growth of corn, are likely to be most exhausted, and which therefore it is most important to supply by artificial manures if he would increase his breadth and produce of corn.

The first point to call attention to in the Tables is the last column of Table II., where we have given for each plot the number of bushels of corn obtained in the first season of 1851, over and above the average of the three succeeding seasons. It is seen that there is in every case a larger produce, by 14 to 20 bushels, or even more, obtained by the same manure in the first year than in the average of the following years. This result speaks well for the previous "*condition*" of the land; and it is also very instructive as showing how useless, for the purposes of any general conclusions, are experiments with manures conducted over a single season only. It is in fact not until some of the elements of fertility, the due proportion of which to the others is comprehended in the term "condition," have been removed from the soil by the crop, that any safe deductions can be formed from the results of experiments with manures. Although it is possible that the field was not quite uniform as regards the accumulation from previous manures, it is at the same time not surprising that we should find the excess of produce in the first year greater on some of the plots than on the others, when it is remembered how very variable were the conditions of growth provided by the experimental manures, and also how different would be the progress or tendency of growth, and consequently the influence of the varying season, dependent on the varying supply of the elements of growth by manure. It is however very unfortunate that the quantity of *straw* as well as corn was not ascertained in the first year; for it is exceedingly probable that had it been so, there would have been found to be a much greater uniformity in the excess of the *gross* or *total produce* of the first year over that

of the others, than is observable in that of the produce of *corn alone.* We now proceed to a study of the results of the individual manures; and in the course of it it will be rendered pretty obvious what was the nature of the unexhausted matters of previous manuring, which gave this greater produce in the first year of the experiment.

Plot 1, which was unmanured, gave 39½ bushels of dressed corn the first year, 15½ the second, 21½ the third, and 16¾ the fourth; the average of the four years being 23¼ bushels, and that of the last three years nearly 18 bushels; which latter amount is nearly 22 bushels less than was obtained on the same plot in the first year. This average of 18 bushels per annum yielded after the condition of the land derived from recent previous manuring had been reduced by the first crop, is very nearly exactly that obtained annually on the much heavier soil of Rothamsted. This is a result which would scarcely have been anticipated; and it shows that, at any rate for the present, the annually available supplies of minerals in the soil are fully equal to the not very widely differing atmospheric resources of the two localities, as judged both by the results obtained, and by a comparison of the meteorological registries of the several seasons.

Plot 2, which was manured with salts of potash, soda, and magnesia, and super-phosphate of lime, gave 34½ bushels of dressed corn in the first year, rather more than 19 in the second, 19¾ in the third, and 18½ in the fourth. It is seen, therefore, that there is only a variation of about 1 bushel during the last three years; and that the average of these last three years is about 15 bushels less than was obtained in the first year. It is obvious that whatever were the elements of fertility present in the soil which were the source of the larger crop of the first year, they were in no way restored by the mineral substances supplied in the experimental manure. Again, comparing the produce of this mineral mixture with that of the unmanured plot, we find that taking the four years together there was actually rather more corn obtained without manure than by the minerals; the tendency of the latter being to increase the growth of straw, of which, taking the last three years together, there was about half a ton more obtained by means of the minerals. It is obvious therefore that mineral manures alone did little to remedy the characteristic exhaustion induced by the growth of the first crop of wheat, and that the annual mineral supplies of the soil were at any rate equal to the natural annual supply of nitrogen available for the growth of the crop.

In the next experiments (Nos. 3 and 4), the manure employed in each case consisted of 200 lbs. of sulphate of ammonia and 200 lbs. of muriate of ammonia per acre; but on Plot 3 they were sown in the autumn at the same time as the manures of all the

other experiments, and on Plot 4 they were top-dressed in the spring. Looking to the columns of *total* produce (Table II.), we see that, taking the four years together, there is a difference of less than 2 bushels between the produce of the two plots, it being however rather in favour of the autumn-sown manure. The autumn-sown manure also gives on the average (see Table III.) a rather better weight per bushel. The produce of straw, taking together the three last years (it not being weighed in the first), is nearly identical in the two cases, there being a difference only of 8 lbs. in favour of the spring-sown manure. Upon the whole, then, the results are in favour of sowing these soluble manures in the autumn even in so light a soil. Comparing the produce of the different years by ammoniacal salts alone, we find that there is here again a fall in the produce of 18 bushels in the one case, and of 14½ in the other, from the first year to the average of the three last years; and that there is afterwards something like a gradual reduction from year to year. It is obvious, therefore, that the amount of nitrogen supplied in this large dose of ammoniacal salts is in excess over the annually available minerals of the soil, which it would appear are becoming gradually reduced. That these, however, are nevertheless considerably in excess over those required by the natural supplies of nitrogen, is obvious from the fact, that whilst by mineral manures alone we got no increase of corn whatever, and only a total increase of straw in the last three years taken together of about half a ton, the ammoniacal salts alone have given in the four years a total increase of 31 to 32 bushels of corn, and in the three last years of 2830 lbs. of straw. By the comparison, then, of the results of the mineral manures alone by the side of those of the ammoniacal salts alone, we have beautifully illustrated not only the nature of the characteristic exhaustion induced by the growth of the corn, but we are also able to form a pretty clear idea of the actual degree or extent of that exhaustion, much more so at any rate than we should be by any analysis of the soil.

In Experiment 5, we have in the manure both the minerals of Plot 2, which gave no increase of corn and but little increase of straw, and the ammoniacal salts of the Plots 3 or 4, which gave a considerable, though annually decreasing, amount of increase. The result of this mixture of both minerals and ammoniacal salts is to give, taking the 4 years together, from 53 to 54 bushels of corn and a large quantity of straw more than is yielded by the minerals alone. This, then, is an annual average of 13 to 14 bushels of corn and an equivalent of straw due to the ammoniacal salts. And since there is in the 4 years about 20 bushels more increase by the mixture of both minerals and ammonia salts than by the ammonia salts alone, it is obvious that the minerals of

this last 20 bushels of the total 53 of increase were derived from the mineral manures employed. This is, therefore, conclusive proof that these minerals were supplied to the land in a form capable of being rendered available for the growth of the plants; and it is therefore clear that the inability of the minerals when used alone, to increase the assimilation of organic constituents from natural sources, was not due either to their not containing soluble silica or other mineral matters required by the wheat-plant, or to an unavailable form of those constituents which were supplied.

In the next Experiment (No. 6), the manure consisted of 2000 lbs. of rape-cake per acre. As already explained, rape-cake contains a large amount of carbonaceous organic matter, a considerable quantity of nitrogen, and also some mineral matter. The quantity applied—namely, 2000 lbs.—was estimated to supply annually about the same amount of nitrogen (but in a different form of combination) as the ammoniacal salts in Experiments 3, 4, and 5 respectively. It also supplied as much of the more important minerals as would be contained in the *increase* of produce which was obtained by it. If, therefore, the total increase of produce obtained by the rape-cake should be pretty nearly the same as that yielded by the minerals and ammonia of No. 5, which contained, as has been said, nearly the same amount of nitrogen, but *no carbonaceous organic matter*, we can only conclude that the latter in the rape-cake has had little to do with the increase; and, in fact, that this is attributable to the supply of nitrogen and minerals afforded by the rape-cake. A comparison of the results obtained by the nitrogen and minerals of No. 5, and by the nitrogen, minerals, and carbonaceous organic matter of No. 6, shows that, taking the average of the 4 years, the latter gives about half a bushel per annum more corn, but about 90 lbs. less straw than the former. It is true that although the *average* produce of the minerals and ammonia of No. 5 and that of the rape-cake of No. 6 are so nearly identical, yet the produce of the two varies considerably in the individual years; but this can scarcely be wondered at, when it is remembered in what a very different form the nitrogen existed in the two manures, and also how differently the degree of their solubility, and consequently the stage or tendency of growth of the plant, would be influenced by equal conditions of climate. The average results are, however, as already stated, all but identical, and we are therefore justified in deciding that in this experiment, as well as in the former ones, the increase of produce was measured by the amount of nitrogen supplied by the manure in a form available for the growth of the crop—provided, of course, the necessary minerals were not absent; and further, that the carbonaceous organic

matter is of itself of no practical utility as a manure for wheat. It may be mentioned that this is a result precisely similar in character to that which has been obtained in the Rothamsted experiments.

The next and last Experiment is No. 7, in which 14 tons of farm-yard manure were applied per acre annually. It has already been stated that this amount of farm-yard dung would supply more of every constituent than would be contained in the increase of crop due to its employment. It would contain, in fact, from 3 to 4 tons of carbonaceous organic substance, whilst the annual increase of produce did not contain 1 ton of such matter. The minerals in the dung would also very far exceed those in the increased produce yielded, and its nitrogen would be greater in amount than that supplied in the ammoniacal salts of Experiments 3, 4, and 5, or in the rape-cake of Experiment 6. There would, however, be this difference as regards the nitrogen—namely, that whilst that which was supplied in the ammoniacal salts would be the most readily dissolved in the soil, that in the rape-cake would be so in a less degree, though much more rapidly in a light soil than in a heavy one. Part of the nitrogen of the dung too would also be rendered easily available, but that portion which entered into the composition of the straw would probably require some years before the whole was liberated and applicable for the growth of the crop. The result of the experiment with the dung is, that we get an average annual increase by it of about 10½ bushels of corn and 1300 lbs. of straw, which is less by nearly 3 bushels of corn and about 150 lbs. of straw than was obtained by the rape-cake. The weight per bushel of the corn grown by the dung was, however, on the average about ¾ lb. heavier than that by the rape-cake, which will account for part of the deficiency. Now, as we have seen by the other experiments, that neither minerals alone, nor carbonaceous organic matter, had any influence in the increase of the crop, but that wherever there was a supply of nitrogen in the manure there was always a very considerable increase, we have every reason to conclude that it was the amount of nitrogen liberated from the dung in a form applicable by the plants which fixed the limit to the increase of produce obtained by its use. And in confirmation of this conclusion, it may be recalled to mind how very small would be the amount, both of the carbonaceous organic matter and of mineral matter, in the increase of produce obtained in proportion to the amount of either of them supplied by the farm-yard manure. It is true, that neither is the amount of *nitrogen* contained in the increased produce of wheat ever equal to that supplied in the manure which yielded that increase; but it must be remembered that, besides any liability to loss by

drainage, to which all might be subject, the nitrogen, in several of its forms of combination, is also volatile, and may be exhaled into the atmosphere and lost, but this is not the case with the mineral constituents of manure.

Upon the whole, then, a careful study of the various experiments has proved,—

That the soil, even with the most unusual and very exhausting process of carrying off the land the total grain and straw of several successive corn-crops, after a root-crop which had also been drawn from the land, still contained a larger annual available supply of minerals than the annual natural supplies of other constituents, nitrogen or carbon, were adequate to turn to account;—

That the excess of the annual supply of minerals in the soil over that required to appropriate the natural resources of nitrogen, is proved, by the effects of ammoniacal salts alone, to have been equal to the further growth, during 4 years, of about 32 bushels of wheat, or an average of about 8 bushels per annum;—

That beyond the increased annual produce which the supply of minerals in the soil was adequate annually to provide when nitrogen was not wanting, the average capabilities of the climate were competent for the maturing of a still greater produce, if additional minerals as well as the ammoniacal salts were provided; and, in that case, from once and a half to twice as much corn was grown as the natural supplies of nitrogen, even with a most liberal supply of minerals, were sufficient to produce;—

That carbonaceous organic matters (such as are contained in rape-cake and farm-yard dung) are of themselves of little or no effect in increasing the growth of wheat.

We can now have little difficulty in deciding to what accumulated elements of growth to attribute the higher "*condition*" or *greater fertility* of the first year, as compared with the succeeding ones. Mineral manures alone have had no effect in restoring the fertility which was exhausted by the first experimental crop. Ammonia alone gave a produce of several bushels more than the unmanured plot in the first year, and has, on the average of the last 3 years, given half as much again of produce as either the unmanured or the mineral manured plot; and the addition of minerals to this ammonia, has restored a further increment of the lost fertility. In no case, however, have the artificial manures of subsequent years entirely restored the original fertility: or rather, in no case (with it is true a difference of season), has there since been a produce quite equal to that of the unmanured space of 1851. From the above facts it is obvious that in the first year there existed in the soil a larger supply both of available minerals and of available nitrogen than in any of the succeeding years; but that in the first year there existed accu-

mulated available minerals in the soil *considerably in excess* of the accumulated *nitrogen* available for the growth of the crop; and that it was the limited amount of the latter, and not of the former, which fixed the limit to the amount of produce of the unmanured plot in the first season—that is, so far as the greater amount of it that year was due to manurial constituents independently of the climatic variations of the different seasons. In a word, the practical fact is elicited, that by the growth of corn in a soil which has been cultivated in an ordinary manner with rotation and home-manuring, the supplies of available minerals are not nearly so soon exhausted as those of the available nitrogen. In fact, the soil has been reduced from a comparatively *high wheat-growing condition* to a very low one, by the exhaustion of its immediately available floating stock of nitrogen; and it was in this very *low wheat-growing condition*, notwithstanding that the mineral elements of fertility still existed in it in such an excess in relation to the natural resources of nitrogen, as was sufficient for an increase of crop during a succession of years, provided only that *nitrogen* was artificially added to it.

What, then, is the lesson to practical farming which these experiments should teach us? It will not be supposed, that because it is here shown that in a cultivated soil of a comparatively light character an increased growth of wheat may be obtained over a continuous series of years by the use of nitrogenous manures alone—that hence rotation and home-manuring should be abandoned, and that corn-crops should be grown continuously by means of nitrogenous artificial manures? There cannot, however, be a doubt of the legitimacy of the inference from these and other experiments, that provided the land receive in a course of years a due share of the home manures derived from feeding of horses and other stock on the farm, the mineral supplies of the soil will be amply sufficient to sustain an increased and even repeated growth of corn, by means of nitrogenous artificial manures, considerably beyond that which is recognised by the leases or the current practices of the day; and a further assurance that the necessary minerals are not likely to become deficient, under the judicious adoption of such an increased growth of corn, is to be found in the fact that there are few really large sources of nitrogenous manures which do not, at the same time, bring upon the land a considerable amount of some of the more important minerals also.

XIII.—*On the various Breeds of Sheep in Great Britain, especially with reference to the Character and Value of their Wool.* By JOHN WILSON, Professor of Agriculture in the University of Edinburgh.

THE classification of the various breeds of sheep of this country is usually determined by the relative characters of their fleeces, these characters rendering the fleeces of each division respectively more or less applicable to the same purposes. Thus we have two well-marked classes—the "*long-woolled*" and the "*short-woolled*," and a third, whose characters are not so definite as to partake entirely of either, to which the term "*intermediate*" may be applied. Of the "*long-woolled*" we may take the Lincoln, the Leicester, and the Cotswold, as the more prominent types; of the "*intermediate*" we may take the Dorset, the Cheviot, and the Radnor breeds; and of the "*short-woolled*" division the Downs, the Merino, the Welsh, and the Shetland are perhaps the best examples.

As the industrial application of these different wools will be more fully considered in the second division of the subject, I will here confine myself to a general statement of their uses. The "long-wools" are used entirely for the various kinds of worsted manufactures, the Lincoln and other glossy wools being used for lustre-goods, &c.; while the Romney Marsh and some of the Irish are in great demand in the French market for similar purposes. The "intermediate" are almost all used for invested yarns; where the character, however of the wool is kempy (as in some of the Scotch) they are found to be more suitable for low woollen goods, as carpets, blankets, hosieries, &c. The "short-wools" are used chiefly for woollen purposes, the longer portions of the fleece being separated and used for worsted yarns and in the manufacture of stuff goods. The two first classes may be termed "combing" wools, and the last class as "carding" wools.

In the following outlines of our different native breeds I have endeavoured to give, in a condensed form, the general physical characteristics and agricultural values of each, confining my observations, save as regards a few occasional references, to the pure breeds, as the limits of my paper would not permit me to do justice to the various crosses between them which are every year increasing in importance both in an industrial and in a more strictly agricultural sense.*

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* The materials from which these sketches of our native breeds of sheep have been drawn, were for the most part kindly furnished to me by the breeders to whom on a recent occasion I applied (on behalf of the Board of Trade) for specimen fleeces of their respective flocks. For the information in reference to the commercial application and value of the different wools, I am indebted to Mr. John Hubbard of Leeds.—J. W.

1st Division.—The Agricultural Characters of the Native Breeds of Sheep.

The Long-Woolled Breeds.

Lincolnshire.—This breed takes perhaps the first place amongst the native sheep of Great Britain, both as regards the weight of the animal and the size of its fleece. The sheep have no horns, white faces and legs, long flat-ribbed bodies, with coarse legs. They grow to a large size on the rich pasturage of the lowlands of Lincolnshire, and produce a heavy fleece, which originally constituted their chief value, the improvement of the carcase being generally less attended to by the breeders than the fleece. For many years a great rivalry existed between them and the improved Leicesters, on which breed probably more attention had been paid to the carcase than to the fleece. At length an union was established between them, and the produce, by a system of judicious breeding, exhibited the leading qualities of both breeds: the coarseness of the animal frame gradually disappeared, the flesh was laid on more uniformly, maturity was advanced fully one year, less food was required, and an aptitude to fatten induced. The ewes were improved, and, when drafted for market, always carried a better condition and fetched more money than the old breed used to do; the fleece was slightly diminished in weight, but was improved in quality. The sheep now are, by the improved system of turnip-husbandry, rendered fit for market as hogs (yearlings); they then weigh on the average 80 to 100 lbs. each; if kept till they are older they become of a large size and not so suited for the markets. An instance may be given of 3 slaughtered, some few years since, aged respectively 3, 2, and 1 year, and weighing 386 lbs., 364 lbs., and 284 lbs. The sheep kept on the higher and lighter soils (the Wolds) are, as might be expected, smaller in size both of carcase and fleece, but possess all the characters of the breed. These generally contain more Leicester blood.

The fleece of the lowland sheep possesses a very long staple with a bright and glossy face, and weighs on the average 10 lbs.,—some considerably exceed that weight. The upland fleece may be taken at 8 lbs.

This breed is met with in some districts crossed with the Exmoor, the South Down, and the Bampton; the usual cross, however, is with the Leicester.

Leicesters.—It was about the middle of the last century when Mr. Bakewell of Dishley, in Leicestershire, began his experiments in the improvement of the breed of long-woolled sheep, at that time common to the midland counties. The old Leicesters

were then considered as possessing many valuable properties, at the same time they possessed many defects. These defects Bakewell sought by a judicious crossing with other breeds to remedy, while at the same time he retained the good points of the original breed. Up to this period the great object of breeders seems to have been confined to the production of animals of the largest size possible, and carrying the heaviest fleece. The old Leicesters are described as large, heavy, coarse-grained animals, the meat having but little flavour, and no delicacy—the carcase was long and thin, flat-sided, with large bones, on thick rough legs. The fleece was heavy and long, and of coarse quality. The sheep were slow feeders, and when sent to market at two and three years old, weighed about 100 to 120 lbs. each. Such were the characteristics of the stock upon which Bakewell commenced his improved system of breeding. Recognising the relation which exists between the form of an animal and its physical tendencies, he sought to cross his sheep with such breeds as he considered would be most likely to ensure those points in the animal frame which were defective in the old breed, and thus to induce an aptitude to lay on the largest possible amount both of flesh and fat in the shortest space of time, and at the least expenditure of food. The fleece too was not forgotten, as that would necessarily share in the general improvement of the animal. Of course time was required to develope the progressive improvements of his system, and also to overcome the prejudices of his day, and obtain for his improved breed that recognition which has since been so willingly accorded to it. Satisfied himself at an early period of his career that the principles he was carrying out were correct, and would finally be crowned with success, he commenced the practice of letting out his rams for the use of other breeders. This plan was not very encouraging at first: indeed it was not until after the lapse of some twenty years that it was appreciated in the manner it deserved. In 1760 we find his rams being let at 17*s.* 6*d.* each. This was increased in the following years to one, two, and three guineas; but it was not until 1780 that he began to receive a remunerating price for them. That year they reached ten guineas, the price rapidly advancing each year with the increasing reputation of his breed. In 1784 the price had risen to 100 guineas for his best rams. In 1786 one of his rams brought him in 300 guineas; and in 1789 he received 1200 guineas for three rams; 2000 guineas for seven others; and he received no less a sum than 3000 guineas from the Dishley Society, then just instituted, for the use of the remainder of his stock. It is worthy of remark that, for the use of one of his rams named "Two-pounder," he received 400 guineas each from two breeders, at the same time reserving to himself the right to

put one-third the usual number of ewes to him, thus estimating the value of the animal at 1200 guineas for the season. At this period many breeders, associates of Bakewell, and following up his system, extended the reputation of the breed and shared in its advantages. In 1793 the flock of ewes, 130 in number, of Mr. Paget of Ibstock, was sold by auction, for the gross sum of 3200*l.*, or for the average sum of 25*l.* 17*s.* each. Others were also disposed of about the same period at very high prices.

In order to obtain a permanent character to his breed, after he had by continued crossing secured all those points he considered desirable, Bakewell carried on his breeding with his own blood, and did not scruple to use animals closely allied to each other. This system, adhered to more or less during a course of years by his successors and by later breeders, while sustaining the purity of the breed, had the effect of lessening its value to the farmer. It gradually exhibited a weakened constitution, became reduced in size and more delicate in form—the ewes were less prolific and less generous to their offspring. These prominent and serious defects soon craved the attention of enlightened breeders, who, by a judicious introduction of new blood, have again restored the original character of the breed, with all the improvements resulting from the advanced system of cultivation, and the enlarged area of sheep-farming of the present day.

The *new Leicester* is now perhaps the most widely extended and most numerous of all our native breeds. The sheep are without horns, with white faces and legs; the head small and clean; the eye bright; neck and shoulders square and deep; back straight, with deep carcase; hind quarters tapering towards the tail and somewhat deficient when compared with the Cotswold sheep; legs clean, with fine bone. The flesh is juicy, but of moderate quality, and is remarkable for the proportion of outside fat it carries.

They are not considered so hardy as the other large breeds, and require shelter and good keep. The ewes are neither very prolific nor good mothers, and the young lambs require great attention. Early maturity and aptitude for fattening are the principal characteristics of the breed, a large proportion of the wethers finding their way to market at twelve or fifteen months old, and weighing from 80 to 100 lbs. each; at two years old they average 120 to 150 lbs. each. The wool is a valuable portion of the flock, the fleece averaging 7 lbs. each.

The occasional introduction of a little Cotswold blood into a Leicester flock has the effect of improving both the constitution of the animal and also the hind-quarters, in which the Leicester is somewhat defective. Ram-breeding is carried out to a much larger extent with this breed than with any other.

Cotswolds.—The range of Oolite hills running from north-east to south-west, and occupying the eastern division of Gloucestershire, have given their name to a breed of sheep, which probably is one of the oldest recorded native breeds of the country, and which, owing to recent improvements, is now rapidly increasing in public estimation. Mention is made of them in history in the early part of the fifteenth century; and in 1467, according to Stow, certain of these sheep were by permission of the King Edward IV. *exported to Spain.* At that period, and for more than two centuries afterwards, the range of the Cotswold Hills formed broad, uninclosed, and bleak tracts of country, affording no natural shelter, but covered with a short sweet herbage. The Cotswold sheep of that day, though possessing the type of the present breed, were, judging from the country they occupied, probably very different from them in size and general external appearance. This question has been disputed by many writers: the result seems to be that there are no physiological reasons nor agricultural facts to disturb the pedigree of our present breed, or to render its altered and greatly improved characters inconsistent with the improved state of cultivation of the whole Cotswold district. It is one of the largest of our native breeds; the long loose fleece adding to the appearance of their large proportions. They are without horns, and have white legs and faces, with a strong tuft of wool covering the forehead, more prominently in the male than in the female. The neck and forequarter are somewhat deficient when compared with the Leicester; the back is straight, body well ribbed up, with deep flanks, hind quarters square and full; the legs are clean, of moderate length and bone. They are hardy, active, and exhibit the appearance of a good working animal, well suited for the range of pasturage the district affords. This pasturage, which consists chiefly of sainfoin, is peculiar to the country. On this the sheep thrive when not stocked too close; at the same time their early maturity and disposition to fatten enable them to be brought to market at 12 to 15 months old at an average weight of 100 lbs.; at 2 years old they will weigh from 120 to 150 lbs. each. The meat when young is succulent and well flavoured; at 2 years old it becomes too fat and coarse to be generally esteemed.

The ewes are prolific, good mothers, and the lambs are covered with a thick, close fleece. The wool produce is an important item in a Cotswold flock. The fleece, which is closer upon the body than the Leicester, averages 7 to 8 lbs. each. The staple is long, mellow to the hand, though somewhat coarse in quality.

The practice of breeding rams for sale or for hire is extensively carried out with this breed.

Romney Marsh.—The breed of sheep met with in the Romney Marshes has long been recorded as peculiar to the district, occupying the same locality, and still to a great extent preserving its own particular characteristics amidst the many changes and improvements that have so materially influenced other breeds. Attempts have been made at various times to introduce Leicester blood into the flocks, but they have not been altogether successful : the shape and points of the animal have been improved, an earlier maturity and aptitude for fattening obtained, while at the same time the size of the sheep has been somewhat diminished, and the fleece, though improved in staple, has been reduced in weight. It has also been found that if the Leicester stain predominates, or even exceeds a certain point, the natural hardihood of constitution is changed, and the sheep become too tender for their exposed pastures. The characteristics of the pure breed are as follows:—The head and legs are white; the head long and broad, with a tuft of wool on forehead; no horns; neck long and thin; breast narrow with moderate forequarters; the body long with flattish sides and sharp chine; loins wide and strong; the belly large; thighs broad and thick; and legs and feet large, with coarse bone and muscle. They are very hardy, and are well adapted for the bleak and exposed district of the Romney Marshes. They also bear stocking closer than other breeds, as it is not unusual to see 6 to 8 fattening sheep placed to the acre. The improved breed produces sheep ready for market at from 2 to 3 years old, weighing from 120 to 140 lbs. The fleece is valuable, weighing on the average 8 lbs. Being long in the staple with a bright and glossy surface, it is sought after for special uses, and is sold largely in the French and other markets on the continent.

Black-faced Scotch.—The origin of this breed is somewhat uncertain. By some it is considered to be an indigenous breed, by others to have been introduced from England about the middle of the last century, when sheep-farming began to occupy the attention of the Highland farmers, and gradually to displace the herds of cattle that then formed their chief support. The characteristics of this picturesque breed readily distinguish it from the other breeds. They have horns: those of the male are of large size and spirally twisted, with two or more curves; in the female sometimes they are absent. The face is black, rather thick at the muzzle, the eye bright and wild, the body somewhat short and square, the fore quarter not so low, and the legs not so long, as in most mountain sheep. They are muscular and very active, of a hardy constitution, and well adapted to endure the privations and severe climate of the hilly districts in which they are kept. They have also the important property of finding a

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subsistence upon the *heather* with which the Highlands generally abound, and which affords them food even when the surface of the ground is covered with snow. Though a pure mountain breed, their habits are not so restless, and they are more docile than might be expected, and thrive well in the lowland enclosures where the keep is good. Large numbers are annually prepared for market in this way. At three or four years old they average about 60 to 65 lbs. each. The ewes are strong and good mothers, and rear their lambs well, even under the privations and exposure to which they are themselves liable at that season.

Latterly considerable attention has been paid to the breed: not only are the points and weight of the animal improved, but the fleece, which possessed certain defects, has been improved also. The wool, which is loose and shaggy, is lessened in value by the "kemps" or hairs which are mixed up in it. These, of course, reduce the quality of the fleece, which can be used only for the coarsest goods. Good feeding, and a judicious selection in breeding from animals the most free from this defect, have already effected a marked improvement in this respect. The fleece, when washed, averages about 3 lbs.; the practice of smearing, however, is very general with this breed, which, consequently, increases the weight but decreases the value of the clip.

Many crosses are met with between this breed and others, both long and short woolled. That with the long-woolled Leicester and with the short-woolled South Down appear to be the most successful.

Exmoor.—This is a pure mountain breed, indigenous to the Forest of Exmoor and its immediate vicinity, the hilly districts of North Devonshire and West Somersetshire, where it has existed from a very early period. These sheep have horns of varied growth, according to the richness of the pasture on which they feed: the horns of those fed on the richer cultivated lands are valuable for ornamental purposes. Their heads and legs are white, and covered in a remarkable manner with short, thick-set wool. In many cases the head is so completely enveloped, that it is with difficulty that the animal can see through it. The shape of their body resembles that of a barrel, *being rounded at all points*, thus differing materially from the square form of the cultivated breeds; this shape enables them probably the better to withstand the rude climate of their native hills. Such are the principal external characteristics of the pure mountain breed. In the lowland districts the farmers have been in the habit of crossing them with Leicesters and other long-woolled sheep, and have obtained a breed known locally by the name of "Notts" (not horned), which in many respects are considered more pro-

fitable. The "Exmoor" ewes drop their lambs very early, and have the reputation of good mothers for the production of fat lambs for the London and other early markets. The wethers are generally grazed until they are four or five years old, according to their condition and wool-producing powers; they are then sent down to the lowland farms, where they are fattened on turnips and sent to market, weighing on the average from 60 to 75 lbs. each. This is found to be a more advantageous system than feeding them at an earlier age, when the gross weight is less and the market value of the meat not so high. The meat is much esteemed for its fine flavour, and always commands a high price. The fleece weighs on the average from 4 to 5 lbs.; the wool belongs to the *long* wool class, and is of excellent quality, being grown very fine and close upon the body, and of a moderate length. It is the practice also to clip the *stock lambs*, which produce each from 1½ to 2 lbs. of beautiful fine wool, according to their age and the treatment they have received. When these sheep are carefully kept and attended to, on well-cultivated farms, their size, fleece, and general characters rapidly improve, and many farmers assert that they will return more profit per acre than the more highly cultivated and less hardy breeds.

The principal crosses are with the Lincoln and Leicester breeds: these improve both the size of the animal and also the weight and quality of the fleece. Other crosses have been tried with Bampton, Dorset, and Cheviot sheep, but they have not been continued.

Devonshire South Hams.—The district in which this breed is met with is extremely limited, being principally the southern portion of Devonshire, extending from the Vale of Honiton up to the borders of Dartmoor. In physical characters they more resembled the Romney Marsh than any other breed, though they differed from them in having brown faces and legs. Latterly they have been improved by the introduction of Leicester blood; this has had the effect of somewhat reducing the size of the sheep and of causing the colour of their faces and legs gradually to disappear. The points of the animal have been materially improved, a disposition to fatten at an earlier age obtained, and a finer fleece secured. When ready for market, at about two years old, the sheep weigh from 100 to 120 lbs. each; the mutton is well-flavoured and commands a good market. The fleece averages 9 lbs. in weight; the wool is long in the staple and of moderate quality. The practice of smearing the sheep is still followed in the hill districts; this of course lessens the value of the wool produce.

Bampton.—This breed takes its name from Bampton, a village in Devonshire, in the vicinity of which it has existed for some

centuries past. Like most of the old indigenous breeds of the country it has gradually been displaced by the improved breeds, and now it is very difficult to find the pure Bampton unmixed with other blood; a few only remaining in Devonshire and West Somerset. They are usually met with crossed with the Leicester breed and very much resembling them in shape, though somewhat larger in size and hardly so fine in general characters. They are without horns and with white clean faces and legs; they are hardy, but require good pasture. At two years old, if well kept, they average 120 to 150 lbs. each. The meat is juicy, but like that of all large sheep, inferior in quality to the smaller breeds. The wool produce is good; the fleece, averaging 7 lbs., is rather coarse in quality. They are now so intermixed with Leicester blood as to partake more of the character of that breed than of the old stock. Crosses with Lincolnshire and with the Exmoor breed are also met with.

Herdwicks.—This breed is confined to the mountain districts of Cumberland and Westmoreland, where it enjoys the reputation of a hardy and profitable animal, well adapted for the rough and bleak country in which it is kept. The sheep are without horns, and have generally speckled or mottled faces and legs, which become gradually greyish or white as the age of the animal increases. The fleece weighs about 3 to 4 lbs. The wool is coarse and open. On the shoulders and neck it becomes matted and kempy, and is only fit for the common description of goods, as rugs, coarse woollens, &c. When left on the hill pasturage the wethers generally remain until they are four or five years old before they are fit for the butcher; they then average from 40 to 50 lbs. each. The quality of the meat is first-rate and always commands a good price. The ewes are good mothers and produce generally fine strong lambs. They display great sagacity on the approach of snow-storms in choosing situations free from the danger of deep drifts. When the storm reaches them they seek the most exposed part of the mountain, which by the violence of the wind is usually swept clear of snow, and here they remain herded together until the storm has passed, taking care to keep up a continual movement, and thus to trample down the snow as it falls. They possess also the peculiar feature for a mountain breed, that they remain attached to a particular spot or locality, and rarely are met with straying far away from it.

Intermediate.

Dorset.—This is a breed peculiar to a certain district in the south of England, where it has been preserved for a very long period. Both male and female possess horns; they have white legs and faces, the face long and broad with a tuft of wool on the

forehead; the nose and lips black; shoulders low, with straight back and good brisket; the loins broad and deep; legs somewhat long, but with small bone. A breed exists in Somersetshire having the general character of the Dorset, with the exception of the coloured noses and lips; these are of a *pinkish hue*, and the breed is known as the "Pink-nosed Somersets." The Dorsets possess, as their frame would indicate, the physical characters of a hardy, useful breed; they are very quiet and docile, and readily adapt themselves to the different modes of management to which they are subjected. They thrive well on moderate keep, arrive at maturity early, and will feed on turnips up to 80 to 100 lbs. weight at two years old. The peculiar characteristic of the breed, which indeed constitutes its principal value, is the fecundity of the females, and their readiness to receive the male at an early season. If well kept and in good condition, this takes place as early as April; thus the yeaning commences in September, and the lambs are fit for the market by Christmas, at which time of the year they fetch a very high price. Some additional care and feeding are of course required. The ewes, however, are excellent mothers, giving a large supply of nutritious milk, while at the same time they are again ready to take the ram and become impregnated while rearing their early offspring. The fleece is close and heavy, with a staple of moderate length; the average weight may be taken at 6 lbs.

The practice of crossing with the South Down is becoming very general, especially when only lambs are desired; these are shorn and produce from 1½ to 2 lbs. of wool each, which fetches always a higher price than the "teg" wool. For store sheep it is a valuable cross, the produce feeds better, grows to a good size, and yields a finer and heavier fleece than the pure Dorset.

Cheviots.—The long line of hills, the Cheviots, traversing the border counties of England and Scotland, have given their name to a breed of sheep which seem to occupy an intermediate position between the Black-faced breed of the Highlands and the more cultivated flocks of the lowlands and of the south. These sheep are without horns; their heads and legs are white in colour—sometimes, but rarely, dun or speckled; the face good, with lively eyes; the body rather long, on clean, fine legs; the neck and fore quarter, like those of all mountain breeds, are rather light. These, by judicious breeding and management, have been considerably improved of late years. They are exceedingly hardy, and although possessing all the vigour and constitution of a mountain breed exhibit none of their restless habits, and submit with great docility to the restraint of the lowland farms. The natural pasture of the Cheviot range is very good and nutritious, and has aided in the development of a larger-framed

animal than that of other mountain districts. The wethers are usually kept till they are three years old, when they fatten readily on turnips, and are sent to market weighing on the average from 70 to 80 lbs. each. Owing to the climate, the lambing is very late, not until the end of April or the beginning of May. This is always a period of anxiety, as great attention and care are required. The ewes are good mothers; in some districts it is still the practice to milk them for six or eight weeks. This, though yielding a small produce in cheese, is very detrimental to both the ewes and the lambs, who are injured to a greater extent than the return obtained by the sale of the cheese. The breed is met with throughout the whole of Scotland and in the border counties of England. In Ireland and Wales also it has been introduced very successfully into several of the more elevated districts. The fleece averages about 5 lbs. The wool is of medium length and quality. The practice of smearing or salving the sheep before winter is becoming less general every year; it is now confined chiefly to the more elevated districts or the more exposed pastures of the northern counties. The operation, intended chiefly as a protection from the climate, has the effect of lowering the value of the fleece, while at the same time it entails a certain cost both in materials and in labour. The Cheviots have been crossed successfully with the Leicester and South Downs; in both cases the produce has been very satisfactory, showing an improvement in the carcase, the weight and quantity of wool, and an aptitude to fatten at an earlier age than the pure breed. At the same time the crossed breed is more delicate in constitution, and better suited for the lowland farms than for the exposed pastures of their native hills.

Radnor and Welsh Sheep.—The different breeds of sheep met with in Wales need but a passing notice, as, under an improving system of farming, they are gradually being replaced by others possessing superior qualities, and at the same time sufficiently hardy in constitution to withstand the lower temperature and humidity of a mountainous country. The native breeds have but few qualities to recommend them; they are hardy, active animals, capable of finding a subsistence wherever they are placed, but they are very small in size and produce but little wool, and that greatly deteriorated in value by the "kemps" or hairs with which it is mixed. The *higher Mountain* breed is horned, with black faces and legs, and sometimes with and sometimes without horns. They rarely weigh more than from 30 to 40 lbs., even at four and five years old, and their wool produce may be taken at 1 to 1½ lb. each. The Radnorshire breed has assumed almost a distinct character; more attention has been paid both to the breeding and to the general cultivation of the animal. The size of the sheep is

increased and its general character improved; the fleece is heavier, and the quality of the wool is seen by the comparative absence of the "kempy" portions which lower the value of the mountain breed. Leicesters and South Downs are now met with on the rich cultivated lowlands of Wales, while the Cheviot and Highland breeds are seen gradually increasing even on the higher mountain districts of the Principality. The principal crosses are with the South Down and the Leicester breeds; these, upon the lowland farms, are very successful.

Short-woolled Breeds.

South Downs.—The name of this breed is taken from the range of Chalk Hills which, running in an east and westerly direction through the southern portions of the counties of Kent, Sussex, Hampshire, and Dorsetshire, are known generally as the "South Downs." Their elevation is nowhere very great; their breadth varies from one mile to six or eight; and their surface is firm and dry, and covered with a close, short, and sweet herbage. On the south side they dip gradually towards the sea; on the north they are bounded by the rich lands of the Lower Chalk, or of the Wealden formations. The entire district is admirably adapted for the successful development of sheep-farming, both in the wide range and nutritious vegetation of the hill pastures and in the climate; while the proximity to well-cultivated lands stretching along their base insures an abundance of keep, so necessary to sustain the condition and the character of our improved breeds. The South Downs of the present day present probably as marked an improvement upon the original breed as that exhibited by the Leicesters or any other breed. To the late Mr. Ellman of Glynde they are indebted for the high estimation in which they are now generally held. When he commenced his experiments in breeding he found the sheep of small size and far from possessing good points; being long and thin in the neck; narrow in the fore-quarters; high on the shoulders, low behind, yet high on the loins, sharp on the back; the ribs flat, drooping behind, with the tail set very low; good in the leg, though somewhat coarse in the bone. By a careful and unremitting attention during a series of years to the defective points in the animal, and a judicious selection of his breeding flock, his progressive improvements were at length acknowledged far and wide; and he closed an useful and honourable career of some fifty years with the satisfactory conviction that he had obtained for his favourite breed a reputation and character which would secure them a place as the first of our short-woolled sheep. The South Down sheep of the present day are without horns, and with dark brown faces and legs; the size and weight have been increased; the fore quarters improved in

width and depth; the back and loins have become broader and the ribs more curved, so as to form a straight and level back; the hind quarters are square and full, the tail well set on, and the limbs shorter and finer in the bone. These results are due to the great and constant care which has been bestowed on the breed by Ellman and his cotemporaries, as well as by his successors, whose flocks fully sustain the character of the improved breed. The sheep, though fine in form and symmetrical in appearance. are very hardy, keeping up their condition on moderate pastures, and readily adapting themselves to the different districts and system of farming in which they are now met with. They are very docile, and thrive well even when folded on the artificial pastures of an arable farm.* Their disposition to fatten enables them to be brought into the market at twelve and fifteen months old, when they average 80 lbs. weight each. At two years old they will weigh from 100 to 120 lbs. each. The meat is of fine quality, and always commands the highest price in the market. The ewes are very prolific, and are excellent mothers, commonly rearing 120 to 130 lambs to the 100 ewes. The fleece, which closely covers the body, produces the most valuable of our native wools. It is short in the staple, fine and curling, with spiral ends, and is used for carding purposes generally.

This is one of the breeds in which the breeding of rams, both for sale and for hire, forms a peculiar feature, as indicative of the value generally assigned to the breed, both for its own intrinsic qualities and for the advantages it offers for crossing with other breeds.

Hampshire Downs.—This rapidly-increasing breed of sheep appears to be the result of a recent cross between the pure South Down and the old horned white face sheep of Hampshire and Wiltshire, by which the hardworking, though fine quality of the former is combined with the superior size and constitution of the latter. The breed was commenced at the early part of the present century; and by a system of judicious crossing now possesses the leading characters of the two parent breeds. In some of the best-farmed districts of Wiltshire, Hampshire, and Berkshire, they have gradually displaced the South Downs, and have in themselves afforded another distinct breed for crossing with the long-woolled sheep. Their leading characteristics are, as compared with the South Down, an increased size, equal maturity, and a hardier constitution. The face and head are larger and coarser in their character; the frame is heavier throughout; the carcase is long, roomy, though less symmetrical than the South

* The farm of Mr. Jonas Webb of Babraham is mostly under tillage cultivation.

Down, and the wool of a coarse though longer staple. Their fattening propensity is scarcely equal to that of the South Down. These points have all received great attention lately from the breeders; and the *improved* Hampshire Down now possesses, both in shape, quality of wool, aptitude to fatten, and early maturity, all the qualities for which the pure South Down has been so long and so justly celebrated. The lambs are usually dropped early and fed for the markets as lamb, or kept until the following spring, when, if well fed, they weigh from 80 to 100 lbs. and command a good market.

The Hampshire Downs are used like the South Downs, for the purpose of crossing with other breeds; being hardier in constitution they are perhaps better calculated for the northern districts, where the climate is sometimes very severe.

Norfolk Down.—This is one of the rapidly declining breeds, having been gradually forced to give way to the superior merits of the South Down. It is now very rarely to be met with, and is confined entirely to one or two flocks in Norfolk and in Suffolk. At the beginning of the present century, when the sandy wastes of the Eastern Counties were being brought into improved tillage cultivation, the hardy nature and constitution of the Norfolk Downs rendered them very suitable for a country where they had to travel daily backwards and forwards from a distant fold, and where the herbage was both scant and inferior in quality. They were horned, and had black faces and legs; rather low in the shoulders and neck, and generally deficient in those points which we are accustomed to look for in our improved breeds. At the same time they were good doers; fattened early, even on poor keep, and produced excellent mutton, with a large proportion of loose fat, which even now renders them favourites with the butcher when they are met with. As the cultivation of those counties advanced, the comparative merits of the district breed and of the South Downs became more decided; and in some trials made on an extensive scale by the Earl of Albemarle and others, it was found that the latter consumed a smaller quantity of food for their size, and gained from that food a superior weight; that being less restless than the Norfolk, they destroyed less by running over it; that the ewes produced a greater proportion of lambs; that the casualties in lambing were less; and that the produce of wool was heavier in quantity and higher in market value. These points, clearly demonstrated, told their tale, and now a pure bred Norfolk Down is but rarely met with.

The cross breed between the Norfolk and the South Down is commonly met with in the Eastern Counties. They are lighter than the South Downs, with very dark faces and legs, and small curved horns.

Shropshire Downs.—In our early records of sheep farming Shropshire is described as possessing a peculiar and distinct variety of sheep, to which the name of 'Morfe Common' sheep was given, f om the locality to which the breed was principally confined. This is a tract of land on the borders of the Severn, near Bridgenorth, which, originally of vast area, has of late been considerably diminished in extent under the influence of cultivation and the general improved condition of the country. In 1792, when the Bristol Wool Society procured as much information as possible regarding sheep in England, they reported as follows in reference to the Morfe Common breed:—"On Morfe Common, near Bridgenorth, which contains about 600,000 acres, there are about 10,000 sheep kept during the summer months, which produce wool of superior quality. They are considered a native breed—are black-faced or brown, or a spotted faced, horned sheep, little subject either to rot or scab—weighing, the wethers from 11 lbs. to 14 lbs., and the ewes from 9 lbs. to 11 lbs. per quarter, after being fed with clover and turnips; and clipping nearly 2 lbs. per fleece, exclusive of the breeching, which may be taken at one-seventh or one eighth part of the whole. The fine wool sells at 2*s.* per lb., and the breeching at 1*s.* per lb., making the produce of the fleece about 3*s.* 2*d.* It is sold to Yorkshire." This appears to have been the original stock from which the present breed of Shropshire Downs has sprung. As the country advanced, and the breeds became valuable for their carcases as well as for their wool, the Morfe Common sheep were crossed with other breeds, but more particularly with the long-woolled Leicesters and Cotswolds, or the short-woolled South Downs. The admixture of such different blood has produced a corresponding variation in the characters of the present breed of Shropshire Downs, and has tended materially to sustain the hesitation which still exists to allow them a place as a distinct breed. Where, however, the original cross was with the South Down, and the breed has been continued unmixed with the long-woolled sheep, they present the characteristics of a short-woolled breed, and as such are already recognised in the Yorkshire and other markets. At the Gloucester Meeting of the Royal Agricultural Society (1853) the breed was well represented, and a large number exhibited, which were thus referred to in the Report:—"The new class of Shropshire Downs was very successful, and it is to be hoped that the Society will recognise them as a distinct breed." These sheep are without horns, with faces and legs of a grey or spotted grey colour; the neck is thick, with excellent scrag; the head well shaped, rather small than large, with ears well set on; breast broad and deep, back straight, with good carcase; hind quarters hardly so wide as the South Down, and the legs

clean, with stronger bone. They are very hardy, thrive well on moderate keep, and are readily prepared for market as tegs, weighing on the average 80 lbs. to 100 lbs. each. The meat is of excellent quality, and commands the best prices. The ewes are prolific and good mothers. The fleece, which is heavier than the South Down, is longer and more glossy in the staple than the other short-wools, and weighs on the average 7 lbs.

Ryeland.—This is one of our oldest breeds, having existed in Herefordshire from time immemorial. Its name is derived from the light sandy districts (old red sandstone) of Herefordshire, which, in early times, were supposed to be only suited for the cultivation of rye. It has always had the reputation of producing the finest quality of wool grown in this country, approaching that of the Merino, to which it bears also a marked resemblance in shape.* The breed, however, is of small size, and the fleece though fine in quality is very inferior in weight to that of other breeds. Many attempts have been made by crossing to remedy these defects, but the success has not been sufficient to induce a perseverance in them, and consequently we find the pure Ryeland sheep every day becoming more rare, being replaced by others of a more remunerative description. In appearance, the Ryeland sheep have peculiar characteristics by which they are easily recognized. They are without horns, with white faces and legs; the wool growing close over the head and eyes with a tuft on the forehead. They are a little low in the shoulder, with a round compact body, and particularly large and full haunches and stern. They are hardy, and thrive well on moderate keep; feed readily for market, and, when at two and three years old, they weigh from 50 to 75 lbs. each. The meat is considered of good quality, the fat being deposited internally instead of on the surface. The ewes are prolific and good mothers; the young

* There are sufficient historical grounds for supposing that the points of striking resemblance between the Ryeland sheep and the Merino may be traceable to actual identity of origin. The coast of South Wales is traditionally said to have been the seat of frequent colonization from Spain. The types of race offer some attestation of this in the dark eyes and hair, swart complexion, and small features of a large part of the Welsh population, extending from the shore of the Bristol Channel, through Monmouthshire, into the south of Herefordshire. But it is also well known that the attraction of the tin-mines in the Scilly Islands, off the coast of Cornwall, brought repeated visits of the Phœnicians from the Spanish city of Cadiz, founded at a period of the most remote antiquity by those enterprising navigators of the Old World. The subtending line of the Welsh coast would receive any vessel drifted by an Atlantic sou'wester beyond its point in those islands, and thus be brought into very early visitation direct from the native country of the Merino. There is a singular evidence of this intercourse in the existence of a remarkable intermixture of words in the Welsh language, identical in form and meaning with traces of the Phœnician tongue. The true breed of the Ryeland is still, though rarely, to be found in its ancient habitat—the light sandy soils in the vicinity of Ross. Though so small, it is the quickest feeder among all our original breeds.—C. Wren Hoskyns.

lambs are somewhat tender and require care for the first week, after which they are pretty safe. The fleece is still valuable, though light in weight, averaging about 4 lbs.

Merino.—This breed, originally introduced into England by the late King George III., though not strictly a native breed, deserves notice here as the parent stock from which are chiefly descended the large flocks in our colonies of Australia and the Cape of Good Hope, from which this country receives annually such large supplies of fine wools. The flockmasters in these colonies are accustomed from time to time to import Merino rams from this country for the purpose of improving their fleeces, as it is found that the Saxon and French Merinos, though producing a fleece of the finest quality, are not altogether so suitable for their purpose, as they are smaller and more delicate in constitution, and give a less return in wool. There are but few Merino flocks in England; those now remaining are descendants of the Windsor flock, Lord Somerville's, Lord Western's, Mr. Trimmer's, and others, and now exhibit a marked difference from the original Merinos, which were essentially a *wool*-producing breed, whereas the English Merinos of the present day are much improved in size, symmetry, and in disposition to fatten; at the same time the fleece has been increased in length of staple and in weight, without any great deterioration of its peculiar fineness.

The average weight of the fleece may be taken at 6 to 8 lbs.; in some rare instances it is met with much heavier. They are hardy, and not more subject to disease than our other breeds; they thrive very well on moderate keep, and may be fed up to 110 to 120 lbs. weight at two years old; the mutton is considered to be of very good quality. It is found more advantageous to cross them with a *long-woolled* than a *short-woolled* breed. When crossed with the Romney Marsh sheep the size and shape of the animal are considerably improved, an earlier maturity and disposition to fatten is acquired, and a heavier fleece, somewhat inferior in quality but with a longer staple, is produced. At the same time they require a richer pasture and more attention than the pure Merinos.

Shetland.—The group of islands forming the northern extremity of Scotland possess a breed of sheep whose hardihood of constitution and capability of enduring extremes of hunger and of cold render it admirably adapted for a country exposed, like the Shetland and Orkney Isles, to such frequent and furious storms, and from which little natural shelter is afforded. But little care or attention is bestowed upon the sheep, which are left entirely to their own resources on the rough uncultivated lands, and are rarely collected together, save for the sake of their wool, when they are marked by their respective owners, and

again turned loose on the moors: the breed consequently has exhibited no improvement, either in carcase or in wool, for centuries past. The sheep are generally polled; sometimes they have small short horns, set wide at their base, more resembling those of a goat than a sheep; the tail is short and very broad, the body rather long, the legs short, with fine bone and strong broad hoofs; the head narrow and well set on. A peculiarity of the breed is, that when their food becomes scarce they at once resort to the sea-coast, and, following the ebbing tide, seek their supplies from the seaweeds with which the shores abound. This gives to their flesh a peculiar flavour, which, combined with the absence of attention to breeding management, renders the meat of a very indifferent quality. The fleece, which constitutes the chief value of the breed, is of various colours, white, black, gray, and brown. Like the covering of other animals exposed to extremes of climate, it consists both of wool and of hair—the one securing the natural heat of the animal, the other being more adapted as a protection against the rain and general humidity of the climate. This hair, locally termed "scudda," grows through the wool, and in the winter forms the outer surface. As the season advances, the wool, the true fleece, becomes detached from the skin, and is then picked off by hand, the sheep being all driven up together for the operation, the hairy portion remaining as a protection to the animal against the weather. The wool has peculiar characters which render it admirably suited for fine hosiery purposes, but, being deficient in felting properties, it is not adapted for combing; about 1½ lb. is obtained from each animal. Within the last few years the increased communication between these islands and the mainland has led to the introduction of Cheviot and other sheep, which, by judicious crossing, must tend shortly to the improvement of the native breed.

2nd Division.—On the General Character, Commercial Uses, &c., of British Wool.

The wool clipped from each sheep is folded by the farmer into a bundle, which is called a fleece.

These fleeces vary considerably in general character and value, according to the different breeds and other circumstances; but, whatever may be the breed, they are generally divided into two classes: 1st, called *hogs* or *tegs;* and 2nd, *wethers* or *ewes.*

Hogs or *Tegs* are the first fleeces shorn from the sheep which have previously not been shorn as lambs. The general peculiarities of these fleeces are that they are longer in staple than the wethers, and the ends of the staples are more pointed

and spiral in their character than those of the fleeces clipped subsequently from the same sheep. The point of the staples of the *first* fleece of the animal possesses valuable properties for certain manufacturing purposes, which do not exist to the same extent in wethers and ewes. In commercial parlance the term *hogs* is applied to the first shorn fleeces of the long, deep-stapled kinds of wool, and *tegs* to a similar fleece of the shorter stapled kinds: for instance, "Lincolnshire hogs" and "Down tegs."

In some districts, it is the custom of the farmers to clip their lambs in the first year, in which case the wool so clipped is called shorn lambs' wool, and is used for certain woollen purposes for which the peculiarity of its first growth renders it especially applicable.

Wethers and Ewes.—These terms are applied to the fleeces shorn from the same sheep subsequently to the hogs, the "wethers" being the second fleece shorn from the sheep: but this term is generally used to denote the *general character* of that kind of fleece, or, in other words, a healthy, sound, good fleece, whether actually the second fleece shorn or not. The term "ewes" is applied, in long-stapled wool, to the shorter, tender, and inferior fleeces which are generally shorn from old or diseased sheep; and in short-stapled wools (such as Downs) it is applied to the shorter grown fleeces, generally both ewes and wethers.

Careful and regular feeding of sheep is well known to have a great influence on the value of wool. As the general rule, whatever keeps the animal in a healthy state promotes the regular growth of the wool, and thereby renders it more valuable for whatever purpose it may be applied. This may be perceived more clearly in the long-stapled kinds of wool, where the want of good or sufficient food is shown in the irregular growth of the wool, by which the staple is rendered tender at that part which was growing when the check to its supply of food took place.

Climate, Locality, and Soil have also a most important influence on the value of wool; rendering some breeds peculiar to certain districts, and changing in a considerable degree the character of the wool upon sheep removed to a locality for which they are not adapted. Thus, sheep of a breed suitable for rich, warm plains, would not thrive so well if transferred to a bleak and mountainous district; and the wool would become coarser at the end of the staples, which (though an effort of nature to adapt the warmth of the clothing of the animal to the more bleak locality to which it had been removed) would injure its value for manufacturing purposes. The influence of soil upon the value of wool may be seen in the different characters of Down wool as grown in the following counties:—In some parts of Norfolk it is much mixed with the blue sand of the district;

in some parts of Hants and Bucks the soil gives it a brown colour and harsh character; in the chalk down districts of Wilts it has a white colour and rather dry harsh fibre; whilst in the rich soil of the Wealden clay of Sussex and Kent, the Down breed of wool is softer, cleaner, and more valuable than in any other part of the kingdom.

These influences of course produce a great variety of wool, but all the kinds may be divided into three general classes, the general characters of which may be described as follows:—

Scotch Cross-bred and Welsh Wools.—These are grown in the mountainous districts of the west and north of Scotland and the western side of England, commencing in the Highlands of Scotland and extending southwards to the mountains of Cumberland and Westmoreland, the moorland district of Yorkshire and Lancashire, and the mountains of Wales. All these have the ends of the staple very coarse, or coarser than the rest of the fleece; and there is generally distributed more or less throughout the whole of the fleece a "*kempy*" or coarse white dead hair, differing in every respect from the character of the wool. The wools are used principally for the manufacture of low woollen fabrics, such as carpets, horse-rugs, &c. Recently some of the better and longer portions have been sorted out and used for low worsted goods.

Down and Short-Stapled Wools are produced chiefly in the district extending from Norfolk in a south-westerly direction to the extremity of Dorset, and included between that line and the coast. In this area occur the exceptional district of Romney Marsh and the rich county of Kent, which produce excellent wool of the deep-grown character. The wools are generally valuable. The tegs and the longer portions of the wethers are used for fine worsted yarns, while the shorter fleeces and shorter portions of the longer ones are used for woollen goods. The Down wools are generally speaking of a rather dry, harsh character, and therefore peculiarly adapted for the manufacture of flannels, for which they are now generally used, as well as for other goods not requiring to be "milled."

The Deep-grown Combing Wools.—These are exemplified by the Lincoln, the Leicester, and other long-stapled sorts of wool. These in their various characters occupy the districts lying between the two already described as containing the breeds producing the other varieties of fleece. These centre districts may be considered generally as extending from the Lothians in Scotland through Northumberland, central and east Yorkshire, Lincolnshire, and the Midland Counties, to Gloucester, Somerset, Devon, and Cornwall. The wools of this description are used for worsted purposes; the length of the staple, the brightness

and fineness of hair, rendering them more or less applicable for each of the great variety of goods now made in the great woollen manufacturing districts.

The fabrics which are manufactured from these different kinds of wool are of course various, but they are described generally by the terms *woollen* and *worsted* goods.

Woollens are those where the shorter-stapled wools are used in the process of manufacturing, in which the fibres of the wool are carded or laid *transversely* and spun into a soft, woolly thread, which is manufactured into cloths, blankets, flannels, carpets, &c. In these the different characters of the wool as to softness are of importance, as will be at once understood, when it is remembered that cloths for some purposes require, after being woven, to be subjected to a process called "milling," by which they are made thicker, and are then called double or single milled cloths, &c. This thickening is effected by the nature of the wool, the fibres of which, during the process, become felted together more or less closely according to the length of time during which they are subjected to it. The wool required for this purpose must be of a soft, rich character; that which is of a dry, harsh nature is not suitable for it. Down wool generally is of this latter description, but the very peculiarity which unfits it for the manufacture of milled cloths renders it more completely adapted for that of flannels, which, from being required to be frequently washed when in use, are always more highly valued when they do not "shrink" or "run up" in the washing. If made from wool of a "milling" character, they would shrink every time they were washed.

Worsted goods are made from longer-stapled wool, which is first subjected to the process of combing, by which the fibres are arranged *parallel* to each other, and are then spun into a small close thread. The goods made from these are known by a great variety of names, such as Moreens, Damasks, Lastings, Merinos, Cobourgs, Orleans Cloth, &c. &c. There is also another kind of worsted yarn made for hosiery purposes, which is carded instead of being combed, and is not spun so closely as the others. These worsted goods consume by far the largest proportion of English wool, and the manufacture of them has, in many important particulars, been improved during the last thirty years, whereby a very large extension in their production has been caused.

As these changes have from time to time had a material influence on the comparative value of different kinds of English wool, it is, perhaps, desirable briefly to allude to them in this place.

In the earlier years of the worsted manufacture long-stapled

and deep-grown wools, such as Lincoln and Leicester, &c., only were used, and the variety of fabrics made from them was not large. In these the "hog" wools were used for the *warp* (or threads running lengthways), and "wethers" for the *weft* (or threads woven across the piece).

The first important improvement was the combing of finer and shorter stapled wools, by which much thinner and more valuable fabrics, such as Merinos, &c., were made, for which a large demand existed for ladies' dresses, &c. This improvement produced a very marked effect on the comparative value of English wool. It brought into use for this purpose the Down teg wools, and the longer staple of the Down wether wools, which were previously used for woollen purposes, and thereby caused a large increase in their value. It also gave a materially increased value to the few Merino flocks which remained in the kingdom, and brought into use, for combing purposes, the longer kinds of Saxony and Australian wools. At this time the warps were still made from wool, and as the hogs and tegs were used for this purpose, it gave a very high value to the best half-bred hogs, which, combining a portion of the length of the deeper grown breeds with the fineness of the Downs, were particularly adapted for the purpose.

During this period some of the lower kinds of foreign wool were also brought into use for coarser worsted goods.

The next very marked improvement in the manufacture of worsted goods was the use of *cotton warps* instead of those made from *wool*. This change has had a most important effect, both upon the extent of the trade and the value of the goods and wool. As regards the value of goods, they are produced cheaper and are made lighter, so as to be adapted for spring and summer wear; whilst the additional introduction of silk warps and foreign wool enables the manufacturers to make fabrics of a more valuable and finer description. Its effect on the extent of the trade has been that, by introducing goods which owing to their lightness and cheapness compete with cotton fabrics, or by their beauty and fineness may be used as substitutes for silks, it has given an immense and legitimate impulse to the increase of the manufacture in the worsted districts.

The change effected in the comparative value of English wool is exhibited in the reduced price of hogs generally, and especially of the half-bred hogs, which were formerly most valuable when the warps of the light fabrics then made were manufactured from wool.

During this period various additional kinds of foreign wools have been brought into use, such as mohair, alpaca, &c. The goods made from these have a bright lustre, and bear a high

price. Lower qualities suitable for more general use have been made by using Lincolnshire and other bright and silky-haired English wools; and these have been brought to such perfection as to be eagerly sought after for light fabrics, for which previously finer and shorter-grown wools were used. Taking into consideration, therefore, the reduction in the value of hogs by the use of cotton warps, and the equalization of prices of the coarse, deep, bright-stapled wools with those which are small and fine-haired, in consequence of the extensive use of the former for the manufacture of lustre goods, there is at present less difference in the comparative value of the various sorts of English combing wools than has existed at any time since fine wools were used for worsted purposes.

Another totally different description of wool is known in the markets as "*skin wool.*"

Skin wool is the wool taken from the skins of sheep which have been slaughtered for food. This is made into various sorts, and used for the same purposes as those for which that character of fleece wool is generally adapted. But, as skin wool is pulled at all seasons of the year, of course it has all the varieties of length of staple, between the extremely short—immediately after the sheep are clipped, and the full-grown wool—when the sheep are ready to be shorn. In the kinds adapted for woollen purposes the whole can be used, the value being greater or smaller according to the length of staple. In the coarse, deep-grown combing sorts the wool is not applicable for combing purposes until it is of the proper length; the early-pulled shorter wool being used for blankets and other low woollen goods, and the intermediate length being used largely for carded yarns for hosiery purposes.

The woollen and worsted manufactures are carried on chiefly in the towns and district extending across the kingdom from east to west, between the ports of Hull and Liverpool. The position between these two seaports is an important advantage, whilst the abundance of coal, iron, and stone, which is found in the same locality, affords a cheap and plentiful supply of the essential materials of the manufacture. The following towns may be considered the centres of the districts where the particular kinds of manufacture referred to are respectively carried on:—

Woollen Cloths.—Leeds and Huddersfield, &c.; and in the West of England, Bradford, Westbury, and Stroud.

Blankets, Low Woollens, and Low Carpets.—Dewsbury, Heckmondwike, &c.

Worsted Goods.—Bradford, Halifax, Keighley, &c.

Flannels.—In Lancashire, Rochdale, Bury, and the adjoining district of Rossendale.

Having made these general remarks, a short account may be given of the commercial estimate of the separate breeds which have been referred to in the first division of the subject. In quoting prices, it must be understood that they are given at their *market value* in the manufacturing districts on the 1st of April, 1855.

Lincoln.—This may be considered the standard of the coarse deep-grown wools for combing purposes, and the wool possesses a bright silky appearance of staple, which renders it peculiarly well adapted for "lustre" goods, in imitation of alpacas and mohair fabrics, and has thus enhanced its value of late years.

The present value of Lincolnshire wethers is about 12½*d.* per lb.; of hogs, 13*d.* per lb.

Leicester.—This old and much-valued breed for combing purposes is rather finer in hair than Lincolnshire wool, but does not possess generally so soft and silky a staple, and hence it is not at present so valuable where those qualities are requisite.

The present value of Leicester wethers is 12*d.* per lb.; hogs, 12½*d.* to 13*d.* per lb.

Cotswold.—A deep-grown breed; the wool similar in quality to Leicester, of a deep and rather harsh character, not suitable for lustre goods.

The present value of wethers is 12*d.* per lb.; hogs, 12½*d.* to 13*d.* per lb.

Romney Marsh.—Soft rich wool, finer in quality than the Leicester. It has been much exported to France, and seems well adapted to the use of the French manufactures. In Kent the lambs are generally shorn, therefore there are very few hogs.

The present value of the Kent fleeces is about 13*d.* per lb.

Devons—South Hams.—A deep stapled breed of wool, grown in the country from which it derives its name. It is the custom of the farmers in Devon not to wash the sheep before shearing them, and the wool being thus in the yolk or grease, is not so marketable as other kinds, which are washed; it is, therefore, usually subjected to the process of combing before being sent to market, and comes in the form of "tops." A double advantage is accomplished by this; the wool is sent in a marketable form, and the noils and short wool, separated in the process of sorting and combing, are sold to the Devonshire manufacturers, who use them. If the wool were washed and shorn in the same way as in other districts, it would be readily saleable. Price about 9*d.* per lb. in the grease.

Bamborough.—Of the Leicester character, from the coast district of North Northumberland. A rich good combing wool, of tolerably fine quality; very much resembles the Leicester, though with more lustre.

The present value of wethers is about 12½*d.* per lb.; hogs, 13½*d.* per lb.

Bampton.—A breed peculiar to Somerset and Devon; deep grown, good average combing wool, of similar kind to the Leicester breed.

The present value of hogs is about 13*d.* per lb.; wethers, 12½*d.* per lb.

South Down.—Small haired wool; the tegs and longer wethers used for combing purposes, and the shorter for the manufacture of flannel and other light woollen goods. There is considerable difference in this wool, from the different localities, both as to quality and softness.

The present value of ewes and wethers is 13*d.* to 13½*d.* per lb.; tegs, 13½*d.* to 14*d.* per lb.

Hampshire Down.—A short wool, very similar to South Down in general character; staple rather longer, and hardly so fine.

The present value of ewes and wethers is 13*d.* per lb.; tegs, 13½*d.* per lb.

Norfolk Down.—The Down wool grown in Norfolk is generally soft in its nature, but usually full of blue sand, which reduces its value. Some of the best and cleanest is very rich and beautiful wool.

The present value of ewes and wethers is 12½*d.* per lb. of sandy, 13½*d.* per lb. of clean; tegs, 13½*d.* to 14*d.* per lb.

Shropshire Downs.—Generally longer in the staple, and with more lustre than the other Down wools. The fleeces vary considerably, according to the original proportion of short-woolled or long-woolled blood crossed with the breed.

The present value of wethers, &c., is 13*d.* to 13½*d.* per lb.; tegs, 13½*d.* to 14*d.* per lb.

Dorset.—Rather longer in the staple and not quite so fine as the Downs, but for combing purposes quite as valuable; clean, white, soft wool. In this country the lambs are generally shorn.

The present value of Dorset fleeces, 13*d.* per lb.; of lambs' wool, 16*d.* to 18*d.* per lb.

Ryeland.—An old breed, almost extinct, very fine and short; formerly used for clothing purposes.

The present value about 13½*d.* per lb.

Merino.—Some years ago there were many flocks of this breed kept in Hants and the adjoining counties: when fine wools were first used for combing purposes this wool realised very high prices; but after the introduction of Saxony and Australian wool for combing, these wools were to be bought much cheaper than the Merino, and it became little used. Merino wool generally came to market much heavier, and not so well washed, as Down wool. It was also much more wasty than Saxony or Australian.

The present value, say wethers, 14*d.* per lb.; of hogs, 15*d.* per lb.; but almost unknown in the market.

Dartmoor.—From the Dartmoor Hills in Devon. Deep-grown combing wool, but coarser and not so well bred as the South Down. Generally shorn in the grease.

Value in the grease about 9*d.* per lb.

Exmoor.—A long-stapled wool of moderate quality; that produced by the polled sheep is usually heavier in the fleece, of a finer description.

The present value of wethers about 12*d.* per lb.; of hogs, 12½*d.*

Radnor and Welsh Mountain.—A moderate combing wool, somewhat coarse in quality and kempy.

The present value of wethers, 12½*d.* per lb.; of tegs, 13½*d.* per lb.

Cheviots.—This is a small haired wool of medium length, suitable for worsted and woollen purposes. It is soft, rich wool, and is liked by the manufacturers. In those districts where the sheep are smeared the value of the wool is considerably reduced.

The present value of ewes and wethers, 12½*d.* to 13*d.* per lb.; of hogs, 13½*d.* to 14*d.* per lb.

Black-faced Highland.—The kind of sheep kept upon the mountains and hills in the Highlands of Scotland; very coarse, and generally depreciated in value by the composition with which the sheep are heavily smeared; used for carpets, rugs, and low woollen purposes.

The present value, 8*d.* to 9*d.* per lb.

Herdwick.—Peculiar to the mountainous districts of the counties of Westmoreland and Cumberland. The wool is used for making low woollen goods, rugs, &c.

The present value about 8*d.* to 9*d.* per lb.

Shetland Wool.—Small wool grown in the Shetland Isles, and used chiefly by the natives for clothing, and occasionally for hosiery purposes.

The present value about 8*d.* to 9*d.* per lb.

Crosses of Breeds.

Leicester and South Downs.—Generally grown in the Leicester district, and formerly much more valuable than Leicester wool. Since the introduction of cotton warps, reduced in comparative value.

The present value of ewes and wethers, 12½*d.* per lb.; of hogs, 13*d.* to 13½*d.* per lb.

Leicester and Shropshire Downs.—A breed of the Shropshire district; longer and more valuable than the Down; good combing wool.

The present value of hogs about 14*d.* per lb.; of wethers, 13*d.* per lb.

Leicester and Highland.—From the Scotch district; suitable for low combing purposes, and more valuable than the pure Highland wool.

The present value of ewes and wethers, 9*d.* to 10*d.* per lb.; of hogs, 10*d.* to 11*d.* per lb.

Leicester and Bampton.—A cross of two breeds, the wool of which is of very similar kind.

The present value of hogs, 12½*d.* to 13*d.* per lb.; of wethers, 12*d.* to 12½*d.* per lb.

Leicester and Norfolk Down.—A very excellent wool, soft and rich; used for worsted purposes.

The present value of ewes and wethers, 12½*d.* per lb.; of hogs, 13½*d.* per lb.

Cotswold and South Down.—A breed of the Cotswold district, suitable for worsted purposes, more valuable than the pure Cotswold breed.

The present value of ewes and wethers, 12½*d.* per lb.; of hogs, 13½*d.* per lb.

Cotswold and Hampshire Down.—Same as Cotswold and South Down.

Cotswold and Shropshire Down.—A breed of the Shropshire district by which greater length is obtained than from the Shropshire Downs alone. Used for worsted purposes.

The present value of ewes and wethers, 12*d.* to 12½*d.* per lb.; of hogs, 13½*d.* per lb.

Lincoln and South Down.—A breed in Lincolnshire finer than the Lincoln wool and more valuable; used for worsted purposes.

The present value of ewes and wethers, 12½*d.* to 13*d.* per lb.; of hogs, 13½*d.* to 14*d.* per lb.

Lincoln and Exmoor.—The produce of two deep-grown breeds; suitable for combing.

The present value of hogs about 12½*d.* per lb.; of wethers, 12*d.* per lb.

Cheviot and South Down.—A breed in Scotland which produces a finer wool than the Cheviots; suitable for finer worsted and woollen fabrics.

The present value of ewes and wethers, 12½*d.* to 13½*d.* per lb.; of hogs, about 14*d.* per lb.

Highland and South Down.—A good combing wool, longer in the staple than pure Down; suitable for clothing purposes.

The present value 13*d.* to 14*d.* per lb.

Dorset and South Down.—A breed of Dorsets; are of equal length with the Dorset and much finer; a soft rich wool, suitable for finer worsted purposes. The lambs are shorn in this district.

The present value of Down and Dorset fleeces, 13*d.* to 13½*d.* per lb.; of lambs, about 18*d.* to 20*d.* per lb.

Merino and Romney Marsh.—The fleece representing this cross-breed is a very beautiful one; an excellent combing fleece; fine, soft, clean, rich wool. When warps were made of worsted would have realised a very high value.

The present value of hogs about 15*d.* per lb.; of wethers, 14*d.* to 14½*d.* per lb.

XIV.—*The Atmosphere as a Source of Nitrogen to Plants; being an Account of Recent Researches on this subject.* By J. THOMAS WAY, Consulting-Chemist to the Society.

No reasoning on any law of nature is philosophical, or can lead us to the truth, unless it embraces a consideration of all existing conditions. A plant lives as it were in two elements: it has its roots in the earth, it throws out branches and leaves to the air. How imperfect a notion should we form of the philosophy of vegetation, if we omitted from our consideration either the one or the other of these necessary conditions of vegetable life! Leaving apart, however, for the present, the first of these, we find, that from the earliest period of the development of true chemical philosophy, the composition of the atmosphere, in its relation to the processes of vegetable nutrition, has been a subject of repeated study; to write a history of the successive steps by which, thanks to the labours of Lavoisier, Priestley, Bergman, Scheele, Black, Cavendish, and many others, we have arrived at our present knowledge of the composition of the air, would be to occupy unnecessarily the pages of this Journal. It is no part of my intention to enter further into the general question, than is necessary to direct the attention of the reader to the bearing of the particular branch of it which I have undertaken to discuss —that is to say, the atmospheric supply of nitrogen to plants. It will, however, be necessary to consider very shortly the composition of plants themselves, in order to see what the constituents are which they must by one means or another obtain.

That the air does in some way materially affect the growth of plants, must have occurred to every mind that has been directed to these subjects.

In the clefts of a rock, or on the ruin of a tower, the seed of a plant is driven by the wind, or dropped by a bird. By and bye moisture and warmth, the principal conditions of germination, cause the seed to grow into a plant, which has a more or less perfect existence, produces seed, withers and dies. In the succeeding years a further growth of the same kind occurs under

similar but improved conditions; by degrees an accumulation of vegetable matter takes place, from the yearly increase in the number of plants, until, a true vegetable mould being formed, the bed becomes fitted for other classes of vegetation, and, in the lapse of time, the barren rock or the ruined tower becomes covered with luxuriant growth.

So in the great forests of the western states of America, gigantic trees flourishing for centuries and shedding periodically their leaves and smaller branches, have formed a bed of vegetable mould, which fifty years of the most scourging crops hardly serve to exhaust. Again, covering hundreds of square miles, and of varying but great depth, we have enormous deposits of vegetable matter compressed into coal. No doubt exists of these beds having been formed by the growth and decay of successive vegetations, precisely in the same way that grass and turf give rise to vegetable mould in our present experience.

Now it can hardly fail to have occurred to thinking men to inquire whence was derived the vegetable matter, which, on the barren rock or the ruined tower, in the great forest or the extensive coal bed, has year by year, and beginning from almost nothing, gradually accumulated:—that the soil does not furnish it is evident, and that the air must do so is equally plain.

A further consideration of the natural composition of plants will show what it is which is thus supplied to them. Apart from the mineral matters of plants, which they may be supposed to derive from the earth, we have four different elements built up into every vegetable structure. It is as impossible for a plant to exist without these, or for a part of a plant to be formed and matured without the full proportion of any one of them, as it is for an infant to live and grow without food.

These elementary substances are, as is well known to most readers, four in number, namely, carbon, oxygen, hydrogen, and nitrogen. It may be stated generally that there are no plants, and no organs of plants, in which the whole of these four elementary substances are not found: they are, however, grouped into two very different classes of substances; the one, as woody fibre or starch, containing the three first; the other, of which the gluten of wheat may be taken as the type, containing in addition the fourth element—nitrogen. We have here little to do with these distinctions, the important point being to bear in mind that the existence of any plant is impossible without the necessary supply of every one of the constituents of its frame.

As I said before, I do not propose to enter upon a history of the various discoveries in relation to the composition of the atmosphere, but with a view to a right understanding of our present inquiry, allusion must be made to some of the results.

The discoveries of Bergman, Priestley, Lavoisier, and others, have shown that the air consists of two gases—oxygen and nitrogen, in the relation of one part of the former to four parts of the latter; these gases not being in chemical combination, but merely in mechanical mixture. Further, it is believed that the chief function of the nitrogen of the air is of a negative character, that is to say, it dilutes the oxygen and prevents the violent action which it would exert in nature if it were not so diluted.

Black investigated the nature of carbonic acid, or "fixed air" as it was first called, demonstrating its production by combustion and the respiration of animals; and subsequent observers proved the existence of this gas in very definite and uniform quantity in the air at all elevations.*

Priestley and Saussure, by the most ingenious and interesting experiments, determined the action of plants in decomposing carbonic acid and appropriating its carbon.

Cavendish made us acquainted with the nature of water, resolving it into its elements, hydrogen and oxygen. He was also the author of a very singular experiment to which we shall have to allude presently.

In air and water, then, we have apparently all the organic elements necessary for the growth of plants; in air, oxygen and nitrogen in abundant quantity; and in lesser but still adequate proportion, carbon in the form of carbonic acid. In water—hydrogen, and a further supply of oxygen. Of the decomposition of carbonic acid and water by vegetation, and the convertibility of their elements into the proximate principles of plants, we have not here to speak; abundant evidence exists of such decomposition and conversion, and it is taken for granted that in this way provision is made for three out of the four organic elements necessary to vegetable growth. If the power of a plant to appropriate the atmospheric nitrogen were equally clear and incontestable, we should have no occasion to go further—the great abundance of this gas as an ingredient, and the chief ingredient of the air, render it superfluous to look for any other source of its supply. The evidence on this point, however, is far from proving the capacity of nitrogen, as one of the constituents of the bulk of the air, to furnish the nitrogen, which, in the form of gluten, vegetable albumen, vegetable casein, &c.,

* It may be remarked in passing, that the proportion of carbonic acid in air has been found to vary from 37 to 62 parts in every 100,000 parts of air. This quantity, small as it may at first sight appear, is, in reference to the whole bulk of the atmosphere, very great. It has been computed by Professor Liebig that it would be adequate to supply the carbon contained in all the deposits of coal on the crust of the globe, and that it is abundantly sufficient for all the purposes of a natural vegetation. Without entering upon the question of the supply of carbon to plants in the sense of their artificial cultivation—a question of the highest

constitutes so very important a class of all organized structures—a class absolutely indispensable to the existence on the earth of animal life.

The object of these pages is to review as fully, and yet as succinctly as possible, in the first place, the various investigations which have been made, with the view of determining this point; and secondly, to call attention to the progress which has, more especially of late, been made in discovering and estimating at their real value other atmospheric sources of nitrogen, in lieu of the great natural supply, supposing it to be found inadequate to the necessities of the case. It would, however, be found very inconvenient to follow these subjects separately, and I shall therefore take them very much in the order of time as the experiments were recorded by their different observers.

Upon the discovery of the composition of the air, it became natural that attention should be drawn to the circumstances under which plants vegetate in it. Priestley, to whose researches upon the chemistry of the gases so much of our earlier knowledge was due, believed that he had found that when plants growing in water were placed in a confined portion of air, they had the effect after a time of reducing the bulk of it very considerably. He considered that in these circumstances the diminution of volume was due to an absorption by the plant of the atmospheric nitrogen; and other chemists (Ingenhouz, Sennebier, &c.), by whom his experiments were repeated, came to the same conclusion. These views, however, were opposed by Saussure, whose experiments on the chemistry of vegetation are far more trustworthy than those of his predecessors. After repeated attempts with the methods adopted by Priestley, he failed to observe any absorption of atmospheric nitrogen by plants. Saussure came to the conclusion that the nitrogen of plants could only be derived from the vegetable and animal matters diffused through the soil, or existing in the form of ammoniacal vapours in the air and brought down by rain. That such ammoniacal vapours do exist in the air Saussure considered to be proved by the change occurring to sulphate of alumina, which, when left exposed to the air, becomes by degrees converted into double sulphate of alumina and ammonia.

To Saussure therefore belongs the credit of having first, although in a very general way, suggested ammonia in the air as the probable source of the nitrogen of plants. We shall presently see how far such an explanation is sufficient to account for the observed phenomena. The earlier experimenters upon these

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interest, and upon which much difference of opinion exists—we may, for our present purpose, admit the sufficiency of this supply for the chief function of plants, namely, the preservation of their species.

interesting subjects of vegetable nutrition laboured, however, under many disadvantages which are unknown to their successors, and wanted many facilities for investigation which these latter enjoy, and we must turn to a later period for any very important inquiry upon the question in hand.

In the year 1825 Professor Liebig demonstrated the presence of nitric acid in rain water, but only in that which had fallen during storms. Of 77 samples, 17 were the produce of storms, and all of these contained nitric acid in greater or less quantity, combined with lime or ammonia. In the remaining 60 he did not succeed in detecting any nitric acid.* Professor Liebig seems to have attached very little importance to this source of nitrogen for vegetation, believing, as he says, that the quantity present in rain water was very small, and would only occur at all during thunder storms, of which there are perhaps not more than ten or twelve in the year. We shall presently see how far he was correct in this opinion.

In the year 1836 Boussingault, whose name is familiar to every student of agricultural chemistry, attempted to settle the question whence and under what form plants obtain their nitrogen. Aware of the difficulties and sources of error to which the experiments of Saussure were exposed, Boussingault employed another and very simple method to ascertain whether plants could obtain their nitrogen from the air, namely, to compare the composition of the seeds with that of the crops produced from them, solely at the expense of the air and water. The great exactness with which the determination of nitrogen could be made, would of course enable him to ascertain with certainty whether the crops contained a larger quantity of this element than the seeds from which they were produced.

Seeds of which the weight was previously ascertained, were sown in burnt clay or in silicious sand, from which all traces of organic matter and ammoniacal salts had been removed by perfect calcination. Porcelain pots were used to contain the soils, and the growing plants were placed in a green-house at the end of a long garden, and watered with distilled water. If under these circumstances the quantity of nitrogen in the crop was larger than that furnished by the seeds, the inference was incontestable that the plants had imbibed nitrogen from the air in some form.

The plants upon which these experiments were made were clover, wheat, oats, and peas. The conclusions to which he arrived from these experiments were that wheat and oats, although increasing in weight from an assimilation of hydrogen, carbon, and oxygen, did not sensibly increase in the proportion of nitro-

* It is to be borne in mind that nitric acid is a compound, from which, if it existed in the air in sufficient quantity, plants might readily obtain their nitrogen.

gen; that, on the other hand, the leguminous plants, clover and peas, had sensibly acquired nitrogen during the experiment. Boussingault, however, came to no definite conclusion as to whether the nitrogen so absorbed by the plant was derived from the gaseous nitrogen of the atmosphere, or from the small quantity of ammonia, which as he says, and as Saussure had pointed out, is always present in the air. In his 'Chemistry of Agriculture,' published in 1840, Professor Liebig related experiments which had been made at Giessen to demonstrate the presence of ammonia* in rain-water and in snow. Believing it to be constantly present in the air, he considered it to be the natural source of the supply of nitrogen to plants. He says, "there is not the slightest reason for believing that the nitrogen of the atmosphere" (meaning, of course, the free nitrogen forming the great bulk of the air) "takes part in the processes of assimilation of plants and animals;" and in another place, "no conclusion can then have a better foundation than this, that it is the ammonia of the atmosphere which furnishes nitrogen to plants."

The importance thus attached by so great an authority in such matters to the presence of ammonia in the air, as the source of supply of nitrogen to plants, naturally led chemists to endeavour to ascertain the proportion of this substance which at different times and under different circumstances the atmosphere might contain.

The first attempt of the kind was made by a German pharmaceutical chemist, named Gräger. His experiments, however, were not conducted with the precautions which are indispensable in so delicate an inquiry, and need not detain us. He found that one million parts of air contained 0·333 parts of ammonia, or one part of ammonia in three million parts of air.

The experiments of Mr. Kemp, an Irish chemist, are open to different but equally strong objections. Kemp made one million parts of air to contain 3·880 parts of ammonia, or one part of ammonia to 258,000 parts of air, or about twelve times as much as found by Gräger.

Fresenius, a former pupil of Professor Liebig's, made a series of determinations of ammonia in the air, which are far more valuable and trustworthy than those just mentioned. He, however, appears to have operated upon too small quantities, and his results are in consequence open to some doubt. Fresenius found that one million parts of air contain on the average,—

By day	0·098	parts of ammonia,
By night	0·169	

* Ammonia is a compound of nitrogen and hydrogen.

or less than half that found by Gräger, and one twentieth of that of Kemp.

M. Isidore Pierre, another Continental chemist, in two analyses of this kind, found in a million parts of air taken at about 12 feet and 25 feet from the ground respectively $3\frac{1}{2}$ and $\frac{1}{2}$ part of ammonia.

It is obvious, however, that the discrepancies between these different experimenters are too great to allow us to draw from their results any conclusion which could be employed in elucidation of questions of agricultural philosophy, or in improvements of agricultural practice—that they proceed either from defects in the methods of examination, or that they indicate very great variations in the composition of the air at different times and under different circumstances is also plain. Perhaps both of these explanations may be in part correct.

We have briefly alluded to these earlier attempts to ascertain the quantity of ammonia in the air, in order that a tolerably correct history of the subject might be given. It is, however, within the last five or six years that the chief contributions to this branch of knowledge have been made, and it is requisite that we should treat somewhat more in detail the experiments which have been carried out, partly to determine the source of nitrogen in plants, and partly to ascertain in reference to the same question the proportion of ammonia and nitric acid in air, and in rain-water. Associated with the former subject we have the names of MM. Ville and Boussingault in France, and with the latter those of MM. Ville, Boussingault, and Barral in France, and of Mr. Lawes and Dr. Gilbert in this country.

I shall take them in succession, commencing with the experiments of M. Ville. The first series of experiments made by M. Ville relates to the proportion of ammonia in the air. They were commenced in the month of June, 1849, and extended over the remainder of that year and the whole of the year 1850. A second series made in 1852 comprised the first six months in that year. M. Ville's researches are marked by a most scrupulous attention to every circumstance which would conduce to a correct result. Fully alive to the sources of error which had compromised the experiments of those who preceded him, he seems to have anticipated and provided against the objections which might be raised against his own.

One great fault of previous attempts to determine the ammonia in the air, was the small quantity of the latter that was operated upon. At the most the proportion of ammonia is remarkably small, and it is easy to understand how in operating upon a small bulk of air the errors introduced in one form or another should exceed the total quantity of ammonia actually present.

The experiment of Gräger before alluded to was made on somewhat less than 40 cubic feet of air, those of Mr. Kemp and M. Fresenius on about 13 cubic feet. M. Isidore Pierre operated upon about 90 and 140 cubic feet respectively. The quantities of air upon which M. Ville made his experiments, varied from 700 to nearly 2000 cubic feet.

M. Ville's method of determining the ammonia consisted in causing a given quantity of air to pass through liquids capable of removing and retaining it. It is unnecessary to describe the apparatus employed by him, and it will be sufficient to state that every precaution was taken to exclude dust, insects, and other substances which might vitiate the results, and that the air was taken from a considerable height from the ground, and at a distance from any source of putrid emanations. M. Ville made altogether 16 determinations of the ammonia in the air. In the first of his experiments, made in the interior of Paris, but in a large garden more than 100 yards from any house, and with air taken from between 30 and 40 feet above the ground, he found the ammonia in 1 million parts of air to be 0·0237 parts. In his second series of experiments, made at Grenelle, in the suburbs of Paris, the proportion of ammonia in 1 million parts of air was 0·0210, or slightly less than in the preceding case. It will be observed that this is very much less (about one-fifth) than that found by Fresenius.

I have carefully considered his statements and his method of examination, and I cannot see any probable source of error; on the contrary, such care and precision seem to have been introduced into this inquiry, that M. Ville's results would appear to merit every confidence. The other question, to a solution of which M. Ville devoted his efforts, was—Can the nitrogen of the air be employed in the nutrition of plants? We have before described the experiments made by M. Boussingault to ascertain whether plants could obtain nitrogen otherwise than from the soil, or manure. He found that they did acquire nitrogen in some form from the air; but his experiments did not show whether it was the atmospheric nitrogen, or whether it was derived from the ammonia. M. Ville endeavoured to fill up this blank in our knowledge of the processes of vegetation. Two methods were employed by him: the first was by means of an apparatus, similar to that used in his other experiments, to supply daily a tolerably large but accurately measured quantity of air to plants growing in glass cases; the ammonia contained in a similar quantity of air was carefully ascertained at the same time. The seeds from which the plants were raised were transplanted as soon as they came up into calcined sand, to which a certain quantity of the ash of similar seeds was added: they were watered with distilled

water. The proportion of nitrogen contained in them having been carefully ascertained by analysis of a similar quantity of the same seed, it only remained to ascertain the quantity of this element present in the crop. If the ammonia in the air supplied was sufficient to account for the excess of nitrogen in the crop over that in the seed, we might be justified in concluding that this ammonia was the source of the increase. If, on the other hand, the gain in nitrogen was more than could be ascribed to the ammonia, we should be forced to acknowledge that some other source of nitrogen, probably the atmospheric nitrogen, had intervened. So reasoned M. Ville. I should add that he supplied to the plants a small quantity of carbonic acid gas, which he found was very necessary to their well-being. The plants operated upon were cress, lupins, rape, wheat, rye, and Indian corn; the result of these experiments was, that the crops in most cases contained considerably more nitrogen than that present in their seeds, and (as ammonia) in the air supplied to them.

M. Ville came to the conclusion that plants assimilate the atmospheric nitrogen. In a subsequent series of experiments made to check the above, M. Ville took measures to deprive the air, before entering the cases, of all the ammonia which it contained, so that any gain in nitrogen of the produce over that in the seeds could not be traced to the agency of ammonia. The result was the same as before—the gain of nitrogen was undoubted, and his first conclusions were abundantly confirmed.

Judging from the account which he himself has given of the methods employed, we cannot sufficiently praise the great intelligence and exactitude brought to bear upon these experiments. It is impossible to detect any source of error, and the results would seem to be in every respect trustworthy; but are we prepared to admit M. Ville's conclusions, that atmospheric nitrogen can be assimilated by plants? This is a question which we shall presently consider.

In a third set of experiments M. Ville shows the effect upon plants of an increased supply of ammonia in the air in which they grow. The plants selected were rape, wheat, rye, Indian corn, tobacco, &c. They were sown as before in sand, and supplied with water and plenty of fresh air daily. To the air of one case the vapour of ammonia was added. The results were most marked; not only was the amount of crops growing in the ammoniacal air increased, but the relative per centage proportion of nitrogen in it was largely augmented. M. Ville, therefore, although believing in the power of plants to absorb atmospheric nitrogen, does not for an instant question the great influence of ammonia on vegetation. On the contrary, he suggests the artificial employment of the volatile carbonate of ammonia in the air

of green-houses to increase the luxuriance of the plants growing therein.

In a paper read before the Academy of Sciences in Paris, in 1851, M. Barral has given the result of his experiments to determine the quantity of ammonia and nitric acid in rain water. Rightly considering that every shower of rain would bring down in solution any portion of these substances suspended in the air, he determined upon the examination of rain as a means of ascertaining the quantity of ammonia and nitric acid which the air contained. It will be remembered that Liebig had failed to discover nitric acid except in the rain of thunder storms. Barral, however, by the most careful experiments, has succeeded in detecting it in the water of rain at all times, at least of rain falling in Paris. The water operated upon by M. Barral was collected in the large rain gauges of the Observatory at Paris. The various quantities falling were collected and analysed for each month, the nitric acid and ammonia being separately determined. M. Barral found very considerable differences in the proportion of each of these present in rain in different months; their quantity was also not at all proportionate to the quantity of rain falling, a circumstance easily comprehended when we call to mind their solubility in water, which would cause them to be brought down in chief part by the first shower that fell. These experiments extended only over four or six months, and cannot, therefore, very properly be said to apply to the whole year. M. Barral has calculated that if the ammonia and nitric acid of the remainder of the year were in the same proportion, an acre of soil in the latitude of Paris would receive annually the following quantities of nitrogen:—

In the form of ammonia	8 lbs.
In the form of nitric acid	16·9 lbs.

M. Barral, therefore, has shown that the nitrogen in the nitric acid of the air exceeds that present in the form of ammonia. He has the credit of being the first experimenter who has succeeded in determining the quantity of nitric acid in rain-water. The objection to these experiments, as the basis of conclusions to be applied to agriculture, is obvious, and would occur to every one, as it did to M. Barral himself, namely, that the air of a city of a million inhabitants, covering an area considerably smaller in proportion than that of London, might well be impregnated with a very much larger proportion of ammonia and nitric acid, the products of animal decomposition, than the pure atmosphere of the country. Carefully and ably as M. Barral's experiments have been made, they are, from this cause, inadequate to furnish any reliable data for the purpose of the agricultural student. We turn now to the later researches of Boussingault.

M. Boussingault had, as we have already mentioned, so early as the year 1837, convinced himself of the fact that nitrogen is obtained from the air by plants, but he had formed no decision as to the form in which this nitrogen was furnished to them. His experiments, undertaken in 1851 and continued to 1853, were intended to clear up this point. M. Boussingault had, as he himself states, the choice of two methods: either to grow the plants in an atmosphere free from ammoniacal vapours—the plan actually adopted by M. Ville; or to place them in a confined atmosphere which was not renewed. For various reasons, to be mentioned presently, he selected the second mode.

The seeds were sown in pumice-stone in coarse powder, previously heated to redness. To the pumice-stone he added a certain quantity of the ashes of farmyard manure, and sometimes a portion of the ash of the same kind of seed upon which he was experimenting; it is obvious that in this way the plant would have a full supply of all the mineral ingredients it could require. These plants were supplied with water free from ammonia, and grown in cases from which the external air was rigorously excluded.

M. Boussingault operated upon haricot beans, oats, cress, and lupins; 12 independent experiments being made. He found that plants thus growing in a confined portion of air did not accumulate nitrogen; that they contained in fact no more of this element than was present in the seed from which they were produced. Such being the conclusion to which he arrived, we are not surprised that his zeal in research should induce him to study more fully the sources and conditions of atmospheric ammonia, to which he was led to attribute the supply of nitrogen to plants.

In the spring of 1853 M. Boussingault made a number of experiments to determine the quantity of ammonia in the water of the Seine and several other streams. He found the proportion very much smaller than from M. Barral's analyses of rain-water in Paris he had been led to expect. He reasons upon the supposition that the water of streams should contain as much ammonia as the rain which gives rise to them. Independently of the fact that the experiments of M. Boussingault, to be referred to presently, prove that the ammonia of rain falling in the country is much less than that of Paris, it should hardly have seemed to him a matter of surprise that such a discrepancy between river and rain-water should exist, if the absorbent properties of the soil for ammonia were taken into account. My own experiments have shown that soils remove the ammonia falling upon them, and the ammonia is therefore, in great part, arrested in its progress towards the streams.

M. Boussingault made at the same time determinations of the

ammonia in rain falling at Paris, which coincided very nearly with those of M. Barral. The ammonia in rain-water he found to be nearly 30 times as much as that of the Seine. He also made two determinations of ammonia in the water of the sea,* taken at Dieppe, and, although the quantity present is very small, the fact of its existence is of the utmost interest and importance: since, considering the immense bulk of the ocean, and that it forms three-fourths of the surface of the globe, it may well have a most material effect in regulating the proportion of this constituent in the air. The presence of ammonia in sea-water could not, however, surprise us when we reflect upon the amount of animal life existing in it, and the processes of animal decay which are continually going on there. M. Boussingault concludes this interesting Memoir by describing determinations of ammonia he had made in snow. It was found, upon comparing water obtained by melting two portions of snow, one taken immediately it fell upon a stone terrace, and the other (from the same fall) after it had lain for 36 hours upon the soil of a contiguous garden, that the second contained ten times as much ammonia as the other.

It is well known that snow has a most beneficial effect upon soils, and, amongst other causes, Boussingault believes that it may act in preventing ammoniacal emanations from the soil. He asserts his conviction that the excess of ammonia in the snow resting on the earth must have been derived from the soil. His experiments, to have been conclusive, should have been made on quantities that had lain for an equal period of time; the one in contact with the earth, the other not so: for from the porous nature of snow it may possess a power of gaining ammonia from the atmosphere which might by possibility lead to the observed differences.

In the autumn of 1853, M. Boussingault made a number of determinations of ammonia present in rain-water, falling at Liebfrauenberg in Alsace, with the view of ascertaining how far previous experiments of M. Barral and himself, made in Paris, expressed the state of the atmosphere in the country and were applicable to agriculture.

He observed, in the first place, that the ammonia present in the first rain that falls is much greater than in that which is subsequently examined. This result is, as was before explained, only what might be anticipated. In one case, after the rain had continued for 24 hours, the quantity of ammonia present in the water was reduced to almost nothing. From the same cause

* These determinations of ammonia will be found in a note at the end of this paper.

it was found that the first rain falling, after a period of 3 weeks without rain, was very much richer in ammonia than usual. In the same year, M. Boussingault examined the water of dew and fogs, collected at Liebfrauenberg, and found them to be very rich in ammonia as compared with rain-water: a circumstance also sufficiently easy of explanation, since the deposition in the state of dew or fog of the watery vapour in the air, would necessarily be accompanied by that of the greater part of the ammonia present, and the quantity of water being comparatively small, would be proportionally rich in ammonia. The result of 75 determinations of ammonia in rain-water, extending from the 26th of May to the 8th of November, and including dew and fog, is stated by M. Boussingault to be, that the water contained on an average ·0344 grains of ammonia in the imperial gallon. M. Boussingault, in the beginning of the year 1854, made determinations of ammonia present in the fogs of Paris, which he found to exceed very largely that existing in the fogs of the country. He also ascertained, a second time, the quantity present in rain falling in Paris, the result being to confirm very decidedly M. Barral's previous researches on the same subjects.

In the years 1853 and 1854, Mr. Lawes and Dr. Gilbert made a series of determinations of ammonia in rain-water. A portion of their results was reported at the last meeting of the British Association at Liverpool; unfortunately the volume of the Transactions for that meeting is not at the present moment (June 1st, 1855) in publication, and I am unable to give any very definite account of their experiments. From a personal inspection of the arrangements, however, whilst these experiments were in progress, I know that they were conducted with that care and attention to detail which characterise all the researches of Mr. Lawes and Dr. Gilbert, and render them so worthy of trust.

The water was collected in a rain-gauge, of very large size, representing a thousandth part of an acre, and placed at an elevation of several feet from the ground, in the middle of a field. The rain, as it fell, passed into large glass bottles prepared for its reception.*

From the reason already given, I am only able to state that Messrs. Lawes and Gilbert's results were, in a great measure, confirmatory of those made by M. Boussingault at Liebfrauenberg. The proportion of nitric acid was also determined in a great many quantities of rain-water.

But Messrs. Lawes and Gilbert entertained so much doubt

* Mr. Lawes's farm is situated at a distance of at least twenty miles in a direct line from London. He informed me, however, that when the wind came to him from the direction of the metropolis, the rain-water collected in the gauge was always slightly coloured by sooty particles.

as to the sufficiency of the existing methods to determine accurately this constituent of rain, that they have forborne to publish their results at present; the general conclusion of their experiments on this head was, that more nitrogen occurred in the form of nitric acid in rain-water than in the form of ammonia, which also, as we have seen, was the case in M. Barral's experiments.

Lawes and Gilbert are still, I believe, engaged upon these important and interesting experiments.*

This brief and somewhat imperfect account of the experiments made upon this most interesting subject, brings me to consider what conclusions, valuable for agricultural theory, and bearing upon agricultural practice, may be fairly deduced from them.

That plants do absorb nitrogen in some form from the air seems evident. I have already mentioned natural occurrences, which would seem to convince us of this fact. At the same time, if this were all the ground for coming to such a conclusion, we might well hesitate. Recent examinations of the ammonia contained in soils, some of them taken at considerable depths, and long out of the reach of cultivation, have shown a large quantity of this substance to exist in them. Whence was this ammonia derived? Not from manure nor from rain, for in one case I examined a clay of the plastic-clay formation, dug 20 feet from the surface; it was physically impossible, one would think, that either air or water could, in any quantity at least, get access to this depth in so close and tenacious a material, yet I found more than 1 part of ammonia in 1000 parts of this clay, and I ascribed its origin then, as it still appears to me it should be ascribed, to the waters of the seas or lakes from which the clay was first deposited, and from which, by its absorptive powers for ammonia, it had removed this alkali in an insoluble form. The existence of ammonia in a soil seems an inherent and inseparable result of the presence of clay in the soil, and we may well question whether all ordinary soils in a state of nature do not contain within reach of the roots of plants, especially of large trees, sufficient ammonia to account for any accumulation of vegetation. It is, however, plain both from M. Ville's and M. Boussingault's experiments, that in the absence of all ammonia in the soil, plants grown in the open air increase in their contents of nitrogen. This point, therefore, is conceded: whence then comes this nitrogen? Ville says—from the nitrogen

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* Mr. Pusey has published, in a late number of the Society's Journal (vol. xiv. part ii.), a determination by myself of the ammonia and nitric acid contained in rain falling in Berkshire. I did not, as I informed him at the time, place very great reliance on the numbers which I obtained, as it is obviously difficult to come at accurate results without special arrangements, both for the collection and examination of the waters, such as were unlikely to be made for the purpose of a single experiment.

forming the bulk of the air; Boussingault believes that it does not proceed from that source, but from ammonia, nitric acid, and possibly other compounds of nitrogen distributed through the air. It does not seem to me at all clear on which side the truth lies, at least as regards the experiments brought forward for the purpose; for as to the general probability, there can be no manner of doubt that it would be that plants do *not* absorb atmospheric nitrogen. Why, if they did so, is a natural vegetation in a poor soil so small and stunted? if plants have this power, why is the limit to it so easily reached? and why again does ammonia so wonderfully promote vegetation, whether the alkali is added to the soil, or, as in Ville's last experiments, to the air in which the plant grows? The evidence is certainly on the general question strongly against the assimilation of atmospheric nitrogen.

Boussingault objects to Ville's experiments, the great difficulty of entirely freeing air from ammonia by passing it through acid liquids, which is quite true. Ville on the other hand objects to M. Boussingault's experiments, the unnatural conditions under which plants are placed when growing in air not renewed, to which M. Boussingault replies that if the plants live, appear to do well, produce leaves, and provide, by the formation of seeds, for a continuation of their species, they cannot be said to be affected materially in their usual functions.

This argument, however, does not seem to me sound. Take an example in the animal creation:—a man engaged in an unhealthy trade. He eats, drinks, sleeps, possesses locomotion, and begets children like other men, but you surely would not argue from all this that his trade is not unhealthy. He performs all his functions in spite of the disadvantages under which he labours; how much better and more healthily he might have done so under other circumstances we can only guess. The plants in M. Boussingault's glass cases may have wanted the *vitality* to make use of a source of nitrogen, of which in more healthy conditions they might have availed themselves. It seems to me then that the question is not definitively settled by these experiments, valuable and interesting as they are.

It is of the less importance for our purpose that this decision should have been come to, inasmuch as it is admitted on all sides that ammonia is a most important ingredient in the air and has the most important effect on vegetation—Ville himself having added it to the atmosphere of plants with signal success. We turn therefore to this head. From all the experiments that have been quoted, we learn that a considerable but as yet uncertain quantity of ammonia and nitric acid exists in the air, and is brought down by rain—that it is larger in cities than in the country—in the

water of fogs and dews than in rain, and in the first showers than in those that fall subsequently—that as a consequence of the existence of ammonia in rain-water, it is found also in the water of streams and rivers, and further on still, in the great ocean; but that the quantity in these cases is much smaller than in rain, owing to causes already alluded to.

Now whence come these ingredients of the air? In the first place ammonia is given off in the decomposition of all animal matters, and of vegetable matters containing nitrogen, and in animal perspiration. Mr. Lawes has also found a great loss of ammonia from the soil in the growth of wheat and other cereal crops: that is to say, he finds that for 1 pound of nitrogen fixed in the composition of the plant, about 4 pounds are taken from the resources of the soil. Now as this does not occur with other plants, at all events to the same extent, it is obvious that this loss is not from evaporation from the soil direct, but through the agency of the plant. Professor Draper's experiments would lead us to believe that ammonia is under some circumstances decomposed, and its nitrogen exhaled by plants. It will be remembered that on the other hand from certain peculiarities of silicate of ammonia, I have suggested that the loss of the alkali observed by Mr. Lawes may be due to the ammonia acting as a carrier to silica, and that it is hence only seen in plants having a silicious character.

Boussingault appears to think that ammonia in some way escapes from the soil, and in this way accounts for snow which has lain on the ground being rich in this alkali. It is generally thought by farmers, that in very hot, dry weather, guano and similar manures are, even when to a certain extent mixed with the soil, liable to loss; but this is only in the absence of rain to bring them well into contact with the soil, and on the other hand it is very generally believed that in the coldest weather manures may be laid on the surface without loss. Whereas M. Boussingault's experiment leading to the inference of the evaporation of ammonia from the soil was of course made in cold weather. The conclusion that under circumstances of perfect mixture with the soil ammoniacal compounds are evaporated from it, seems to me utterly opposed to the fact which I have demonstrated, that when air charged with the ammoniacal vapours is passed over a soil contained in a tube, the ammonia is entirely removed.

Without, however, being over anxious as to how ammonia* comes to be present in the air, or what was its first origin, we may be satisfied that air does always contain it in notable quantity.

* Mulder believes that ammonia may be formed from the nitrogen of the air uniting with the hydrogen of decomposing vegetable matters in the soil.

The same is also now demonstrated with regard to nitric acid. Cavendish made on this subject an experiment, which has already been alluded to. He passed a series of electric sparks through air confined over an alkaline liquid, and found that a quantity of alkaline nitrate was produced, evidently derived from the union of nitrogen and oxygen. His experiment was repeated by Dr. Daubeny.

Since these experiments it has been usual to believe that electricity, developed in the higher regions of the air, is continually giving rise to nitric acid, and, as it appears that electrical action and interchange is always going on, although without the evidence of its existence which thunder-storms give, there may be a constant production of nitric acid from this source. But admitting this to be the case, we are surely placed in the dilemma of accounting for the absence of any apparent increase in the luxuriance of the vegetation of the globe which should follow a constant production of nitric acid, unless some equalizing cause be in existence, such as the decomposition of ammonia and exhalation of nitrogen observed in Professor Draper's experiments.

The mutual convertibility of nitric acid and ammonia, as shown by Kuhlman to occur under the influence, in the one case, of the oxidating influence of the air, and in the other, of the de-oxidating influence of vegetable matter in the soil, would seem to place these two forms of nitrogen compounds on a level as a source of nitrogenous supply, provided the necessary conditions exist for these changes. And the experience of our agriculturists as to the value of nitrate of soda very sufficiently attests the truth of M. Kuhlman's experiments and conclusions.

We have seen then that in the form of ammonia or nitric acid the soil receives annually a very large dose of nitrogen in a state to be made use of by plants. That the data yet obtained are not very precise ought not to surprise us, considering the difficulty of the subject. I think, too, that one point has been overlooked in all these inquiries: one experimenter devotes his attention to the ammonia in rain, another to that in air—both independently, at different times, and without concert. But in the meanwhile a cause, and, as I believe, a most active cause of abstraction of ammonia from the calculations of each of them, is at work;—I mean the absorption of ammonia and nitric acid from the air by the soil.

Between each shower of rain this cause is continually—to an unknown, but perhaps a large extent—robbing the air of these compounds; so that the rain when collected really represents that which this agency has not removed. On the other hand, the quantity at any time present in the air must merely have relation to the distance of time at which it was last swept from it by rain,

and takes no account of that which the soil has in the meanwhile appropriated. To be perfect, these experiments should be made simultaneously on the ammonia in the air and in the rain, and that absorbed by a given extent of surface-soil. This is a labour that we can hardly expect from any one experimenter; and considering the great varieties of soil, the result would even then be but an approximation to the truth. For the present we must be content with this fact, that a quantity of ammonia and nitric acid, equal perhaps on an acre to at least the manuring power of a cwt. of guano, is annually brought down to the soil by rain for the benefit of vegetation. Let not, however, the cultivator deceive himself, and suppose that his duty of manuring his soils is lessened from this circumstance. This fall of manure—so to speak—it is out of his power to control; and to it, no doubt, is attributable, at least in part, the natural fertility of any given soil: his art lies in increasing this natural produce to a point at which the crops will repay the cost of their production. But he may profit by this newly-discovered bounty of nature if he will take full advantage of the atmospheric manure by means of drainage, which promotes the equal flow of water through instead of over his soil; by deep cultivation and thorough pulverization of the land, which brings every part of it into contact with the air. The atmosphere is to the farmer like the sea to the fisherman—he who spreads his nets the widest will catch the most.

The history of inventions is in nothing more remarkable than in the coincidence of time with which many bearing upon each other are made. The invention of the electric telegraph would have been incomplete but for the almost simultaneous discovery of gutta percha, without which submarine communication would probably have been unattainable. So, it is to be hoped, the knowledge now gained of atmospheric sources of manure will soon be followed by a success in adapting that mighty power, steam, to the cultivation of the soil; for nothing is plainer to my mind than that abundant cultivation of the soil, if economically practicable, is an equivalent to the direct application of manure. We draw from our recently-obtained information inducements to fresh efforts in this direction, and are led to suggestions for improvements on other points of agricultural practice, such as green manuring, rotation of crops, and especially irrigation. These facts point to most important conclusions; but at the present moment we must forbear from entering upon them. At some future time, when these investigations have led, as they surely will, to conclusions of still greater importance, we may perhaps be allowed to return to the subject.

NOTE.

Ammonia in One Million parts of Air.

			Grains.
Fresenius		By day	0·1690
		By night	0·0980
Ville	Interior of Paris	Lowest	0·0177
		Highest	0·0317
		Mean	0·0237
	Environs of Paris	Lowest	0·0165
		Highest	0·0276
		Mean	0·0210

Ammonia in an Imperial Gallon of Rain-Water.

Boussingault	Paris	0·2100
	Liebfrauenberg	0·0350
Barral	Paris, mean of five months, August to December	0·240

Ammonia in Snow.

		Grains per gallon.
Boussingault	Collected on the earth	0·454
	,, on a terrace	0·080
	In water of the Seine	0·0096
	In sea-water at Dieppe	0·0136
	In water of dew at Liebfrauenberg, from	0·0714
	to	0·4340
	In water of fog at Liebfrauenberg	0·1790
	,, ,, at Paris	9·600
Barral	Nitric acid in rain water	1·350

Ammonia and Nitric Acid, per acre, in lbs., in Rain-Water at Paris.

Barral	Ammonia	9·60 lbs.
	Nitric acid	65·18

These quantities would yield nitrogen,

In the ammonia	7·90 lbs.
In the nitric acid	16·90
Total nitrogen per acre	24·80

NOTICE.

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THIS being the first Number of the Journal which has not had the benefit of Mr. Pusey's active superintendence, the Journal Committee cannot send it forth without expressing their deep regret at the severe and protracted illness which still deprives hem of his valuable assistance. They are also desirous of recording their high sense of the important services which, in his threefold capacity of Chairman of the Committee, Editor, and Author, he has conferred upon the Society and the country at large. From the very commencement of the Society the labours of the other members of the Committee have been comparatively light, and it is right that the members of the Society should know to whom they are chiefly indebted for the success which has been achieved, for the reputation which the Society's publications enjoy in this and other countries. In their endeavours to maintain for the future the high standard of utility and interest already established, the Committee wish to avail themselves of the active co-operation of the large body of practical and scientific men who compose the Society. Spread as they are over the whole surface of the British Islands, nor even confined to them, they possess singular advantages for the collection of information based upon observation and experiment. The Journal Committee therefore earnestly invite attention to the following Resolution, which formed part of their last Report to the Council, viz.:—

"That in future, under the head of 'Miscellaneous Communications,' a portion of the Journal be allotted to short papers from such members of the Society as may favour the Committee with an account of any matter of special interest which has come under their notice in the management of their farms, or in their immediate neighbourhood."

XV.—*Report on the Farming of Buckinghamshire.* By CLARE SEWELL READ, Barton Hall, Brandon.

PRIZE ESSAY.

THE writer of the subjoined Report, having regard to the desirableness of presenting such information as he has been able to collect in a form most available for general readers, has aimed at condensing and simplifying to the utmost the result of his investigations. With this view, and with the further object of avoiding, wherever it can be done without detriment to perspicuity, all repetition of details which have already found a place in the transactions of the Society, he has thought it proper to state his general conclusions with more conciseness and less frequent reference to individual cases and exemplifications than might otherwise have been done. Thus much he thinks it necessary to premise, lest it should be thought that his inductions have been formed hastily, and drawn from inquiries and observations less extensive and exact than are requisite to the forming a reliable opinion, and that he has not bestowed upon the subject the pains of minute and detailed inquiry.

In two former numbers of the Society's Journal a very long and detailed account is given of the farming in the county of Oxford, which, for a distance of more than 40 miles, joins the county of Buckingham with hardly any natural feature to point out the line of demarcation. Most of the belts which run across one county extend into the other, and form similar kinds of soil which receive similar treatment. If these lines ever obtain a place in the Journal, its readers will probably consider a minute description of customs and peculiarities which are common to both counties to be tiresome and unnecessary. Should it be thought that some observations are too general, such defect may be ascribed to the wish to avoid useless repetition. On the other hand, should any trifling particular be strongly dwelt upon, and so invested with greater importance than it may seem to deserve, it will probably admit of the explanation that such particular has not been previously brought before the readers of the Journal.

The county of Buckingham is somewhat of an oblong form, with numerous indentations and projections. Some of these are of the most whimsical and unaccountable nature. In one spot near the Three Shire Hole, where a straight line of division would be hardly 500 yards, the county line is nearly 6 miles; and in another, where the outsides of Nettleden and Hawridge are not above 2 miles, the county boundary perambulates a distance of

25 miles, without any apparent cause for the irregularity. The extreme length of Buckinghamshire is 53 miles, and its greatest width 27. It contains 730 square miles, or 466,932 acres,* and is divided into 8 hundreds, and 224 parishes or places, having 15 so-called market-towns. Of these the most important are Aylesbury, Wycombe, and Buckingham, which have all good corn-markets, while some have excellent markets for stock or monthly fairs, at which much business is transacted. Aylesbury market is always well supplied with stock, and a large quantity of corn is sold there. Buckinghamshire in 1851 contained 163,723 inhabitants; in 1801 the population was 108,132, being an increase of 51 per cent. in the last 50 years. This increase is about the same as in other adjoining agricultural counties, and the population about as numerous, there being 224 persons to a square mile, and nearly 5 inhabitants to a house. The four towns of Aylesbury, Buckingham, Wycombe, and Marlow, which contain 47,822 persons, return 8 members to parliament, while the rest of the population, 115,901, is represented by the 3 county members.

The climate of this county of course varies with its altitude and aspect. Some elevated portions of the Chiltern Hills are bleak and cold, but generally speaking the temperature is similar to that of other midland counties. The depth of rain is commonly greater than that of the south-eastern district, but this year, as much of the rain came from that quarter, it is less. The following accurate meteorological observations, taken at Hartwell Rectory near Aylesbury, which is near the centre of the county, will give a good idea of the variation of temperature and fall of rain during the last three years :—

	1852.	1853.	1854.
Depth of Rain, in inches	33·886	27·097	14·343
Mean Temperature of the Year	49° 27′	46° 48′	48° 05′

The seasons of 1852 and 1853 were both wet. The depth of rain will readily account for it in the former year, while the number of wet and cloudy days made the latter season damp and cold. The year just passed will long be remembered for its dryness. In the six months of February, March, April, June, September, and November, the fall of rain was only 3½ inches, while for the whole year, as above recorded, it amounted to little more than 14 inches, not half the quantity which fell in 1852. It was a particularly good year for the stiff arable lands of Buck-

* By the 7 and 8 Vict., c. 61, Lillingstone-Lovell, Boycott, and Coleshill were annexed to Bucks, while other outlying parishes were severed from it. By this exchange the county gains 2559 acres and 617 inhabitants. The old Report put down the county at 393,600 acres.

inghamshire, and though the autumn was too dry for roots to flourish, it was just such a season as they required after the preceding drenching summer. The yield of corn was very abundant, and—when the average crops of the county are mentioned no special reference is made to the yield of the present season—5 and 6 quarters of wheat, almost as many of beans, and a larger quantity of barley, were common instances of the yield. The good crops and good prices are making amends for the wretched yield and low prices of former years. But while the arable land rejoiced, the drought was much too severe for the pastures, and there has hardly ever been a season when the grass was so scanty. The spring was dry and very cold, and the late frosts, especially that of the 24th of April, retarded vegetation and destroyed the produce of every early blossom. In consequence of the continued dryness of the summer the hay crops were very light, and though most were well secured, there was a fortnight in July when a great deal of hay was damaged with a very insignificant amount of rain. The harvest weather, particularly during the latter part, was splendid, and as little or no rain fell in September the autumnal grass of the pastures was never abundant. In fact, since the fall of snow in January the ground never had a soaking, and the showers which fell freshened and revived the herbage without producing any great amount of keep.

The geological and agricultural divisions of the county of Buckingham may be treated of under one head, for, though they do not always harmonise in all particulars, yet the different formations plainly indicate a change of soil, and consequently a change of husbandry. Chemical analyses may, by numberless repetitions, assist in forming a correct idea of the nature of the soil, but at the same time they must be multiplied to an inconvenient extent, to exhibit anything like a satisfactory classification of the different soils throughout a county. Not only would the soils from different portions of the same field vary—not only would its depth, its position, and its dryness alter the proportions of its constituents—but whether the land is pasture or arable, in good condition or bad, drained or undrained, foul or clean, supplied with mineral manures or not, in crop or in fallow, in winter or summer,—these and similar modifications ought to be taken into consideration before chemical analyses can present fair comparisons. Such analyses may be very valuable to individual farmers, but they can be of no use in the general description of a county, and the Society very wisely does not consider them essential. Even the Society's learned chemical Professor says, "that the general analysis of a soil would not enable me to point

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out, with anything like correctness, the cause of any alleged fertility; and even a most minute analysis of a soil gives (to me, at least) far from satisfactory data for such conclusions." After such an opinion it would be useless to burden this Report with such uninteresting and unprofitable matter; but as some of the more prominent chemical features of the various soils may be useful in giving a general description, a few of the most important will be introduced.

Beginning the geological description at the extreme south of the county, that triangular part which lies between the three outlying towns of Staines, Maidenhead, and Uxbridge rests on that portion of the tertiary system known by the name of the plastic clay formation. This district may be generally termed a gravelly loam, resting in some places on a gravel, and in others upon a brick earth or clay. The first important development of this clay towards the west is seen at Slough, from whence it passes eastward in irregular patches, and forms the extensive brick-fields around Langley Marsh. Indeed this formation is composed of an indefinite number of sand, clay, and pebble beds irregularly alternating, and so producing soils of the most unlike qualities within very short distances. The sands generally cover the surface towards the north, the clays being only occasionally interposed at considerable intervals. The sands and clays are of various colours and thickness, and of different degrees of purity. A large flat of friable sandy land, well fitted for arable cultivation, extends along the north bank of the Thames. The strip of meadows bounding the river is but thin; and in some parts the arable land, as at Maidenhead Station, reaches to the edge of the stream. The whole of the upland may be considered to be under the plough; and as the soil varies from a clay loam to a burning gravel, several varieties of land, requiring different modes of cultivation, are found in the same parish. From the vicinity of London and Windsor large quantities of straw and hay are sold, which, provided an equivalent is supplied in the shape of manure, may not be detrimental to the district. The railway is but a poor compensation to the land for the numerous coach-horses which were formerly stationed on the great turnpike-road which traverses nearly 10 miles of this locality. Chalk underlies the north portion of the plastic clay, and there pits are sunk and the chalk applied liberally to the land. On some farms to the south calcareous matter is supplied in the shape of lime, but more frequently it is chalk, which is carted from some of the outlying pits. This, or something similar, is particularly needed, as neither the clay nor sand of this formation contains any calcareous matter. This district is, on the whole, well cultivated; and some of the

farms are managed in a very masterly style: this may particularly apply to the agriculture about Burnham, Farnham, and Datchet, where the land is made to constantly produce a series of good crops and yet kept in excellent condition. Indeed this soil will produce capital crops of all cereals, more especially oats. Although winter-beans do not flourish, the spring varieties are produced in perfection; and this portion of the county is celebrated for the fine qualities of its Chidham wheats. From the variable nature of the subsoil there are large reservoirs of water, and much of the land requires draining. It is often troublesome to dry it perfectly; but this may be attained by attending carefully to the veiny nature of the subsoil, and cutting the drains as much as possible across these seams.

At the junction of the chalk with the plastic clay (which might be shown by a line stretching across the county from Maidenhead to Uxbridge), the sands of the latter formation cover the chalk to a considerable extent, and the south side of the acclivity presents a series of barren and uncultivated heaths. Such lands might pay for planting, and some even for cultivation, but the greater part is composed of coarse sand and rounded pebbles, and is naturally so sterile, that with clay easy of access, and chalk to be had by sinking pits, there is no reason to suppose the cost of improvement would ever be repaid. Upon arriving at the higher ground, which commences at Woburn Hill and runs to the south of Beaconsfield, a slight change for the better is manifested; but the improvement is certainly very slight, for in lieu of the sandy heaths there is a certain gravelly soil—wet, hungry, and weak. At Woburn Hill there is a fine development of the chalk, and the varying, overlying stratum of the plastic clay. On the top is a bed of gravel 20 feet deep, then comes a deposit of clay also about 20 feet, and under that lie 4 feet of sand resting on the chalk. The gravel is here used for repairing the roads, the sand and clay in the manufacture of bricks, and the chalk is burned into lime. Proceeding in a north-east direction, the country certainly improves, and presents the favourable features of the Chiltern district. There are tracts of mouldy land full of rounded pebbles; gravelly loams, containing numberless flints, in the valleys; the sides of the banks are chalky, and on the summit of the hills is an argillaceous loam interspersed with seams of gravel and flints. This deposit, which exists in variable quantities nearly all over the chalk-range, is evidently the washing of the plastic clay. On the hills which incline to the south or run down to the Thames, the drift is mostly composed of sand and gravel, while on the elevated tablelands and toward the north the clay appears more general. In

addition to the variety of soils formed by the undulations of the ground, and the difference of the superficial deposits, the soil on the top of the hills, where the ground is quite flat, often varies greatly. Every one, on looking at a chalk-pit, and passing a railway cutting, must have seen the deep indentations on its surface, which are mostly filled with gravel. These are sections of long furrows, and of cavities occasioned by the powerful action of water prior to the deposition of the superior stratum. It often happens that a field, which looks all of the same quality to the eye, has the chalk in some parts within a few inches of the surface, and in another spot close by the calcareous subsoil is covered with several feet of flinty clay. In some parts of the Chiltern hills, especially about West Wycombe, are isolated masses of reddish-yellow sandstone. These stones are evidently formed by the sand of the plastic clay being fused or cemented by some powerful agency. The real chalk is a white chalky limestone, more or less pure carbonate of lime, the constituent parts being lime and carbonic acid in nearly equal proportions. It is not naturally a fertile soil, but, with good farming, will produce almost every crop, and will pay for high farming as well as any soil, as corn does not often lodge on it. This formation is very unlevel, being a succession of hill and dale. The chalk escarpment towards the north presents a series of bold and picturesque hills, known as the Chiltern range. Some of these attain a considerable elevation, as the hills of Wendover and Ivinghoe are both above 900 feet high. As the formation is composed of homogeneous beds of chalk, all with open partings, the water freely percolates through it, and there are no springs. This produces a scarcity of water on the high lands of the Chiltern district, and the supply is principally derived from ponds and tanks. In the majority of seasons these are capacious enough; but last year the continued drought exhausted them, to the serious inconvenience of many homesteads. At the foot of the hills, where the descent of the water is arrested by the lower chalk, or other more retentive strata, springs burst out, and towards the south form some considerable rivulets. Two branches of the Colne rise at Messenden and Chesham, and join the Thames west of Staines; while the Wycombe stream rises a little above that town, and flows from thence to Woburn. These little rivers are turned to the best account, their waters being used for propelling a great number of mills, which are mostly employed in the manufacture of paper. The upper chalk is distinguished from the lower series by the presence of bands of nodular flints, and is mostly in arable cultivation. Some parts are so precipitous as to preclude the use of the plough, and those banks are

either in sheep-walk or covered with beech wood, which appears indigenous to this soil. The upper chalk occupies a considerable portion of the south of Bucks; and if the length of it be taken from Uxbridge to Wendover, it reaches nearly 20 miles; and the breadth, from Cheneys to Fawley, is about the same distance.

The traveller who journeyed from Aylesbury in days gone by—it was certainly an advantage of the slow coach days that one might see the country he passed through—such a traveller then could not fail to observe, when he arrived at Wendover Hill, how totally different was the undulating and fertile plain, which stretched away as far as the eye could reach, from the steep chalky banks and narrow valleys he had traversed for so many miles. And such a prospect, if viewed in the freshness of spring, the luxuriance of summer, or mellowed by the approach of autumn, always presents a scene of mingled beauty and interest. The traveller descends the chalk escarpment, and enters upon the open country of the lower chalk, which here runs in a narrow band at the foot of the Chiltern hills. And the difference of the farming is no less remarkable than the change of scenery. The deep strong grey loam of the lower chalk is substituted for the country of hilly sheep-walks, flinty gravels, and thin chalks, and of course a different style of agriculture is the result. And here it may be noticed, that the prominent and characteristic feature of the county which lies towards the north is essentially clay. It is true there are the Portland oolite at Haddenham, and in detached spots; the greensands about Leighton, and the great oolite beyond Buckingham and Olney; but these strata are of comparatively small extent, and clay spreads itself over the chief part of the county. In this respect it differs from Oxfordshire, where the clay beds are intersected with considerable masses of stratified rock. In Bucks we do not find the upper greensand at the foot of the Chilterns, nor the large development of the coral rag, for that formation ceases at Holton before it enters the county. Neither is there that large stonebrash district, which composes the greater part of northern Oxfordshire. Although the influence of the minor strata is confined to limited localities, of course they will not be overlooked, but it is to be generally wished that some talented geologist would make Buckinghamshire the scene of his special labours, for while the south of the kingdom seems to be the constant field of investigation, this district has been comparatively neglected. In proof of this, the inaccuracy of the present maps might be adduced, for in all of them there are serious errors, and in most the rocky and sandy formations are too largely developed.

But to return to the description of the lower chalk. As already

said, it stretches in a thin belt across the county, begins at Bledlow on the west, and runs by the Risboroughs to Aston Clinton and Drayton. It continues its course across that curious projection of the county, being found below the chalk hills of Ivinghoe. The soil of this formation is more tenacious and fertile than the upper chalk, and may be easily distinguished from it by the total absence of flints. But even on this narrow stratum the soil varies considerably. That at the base of the hills, which is sometimes called white land, is by no means a good soil, while that which lies below the Icknield-way is much better, and capable of bearing excellent crops of wheat, beans, and oats. It is not over-well adapted for the growth of roots, and sheep trampling on it in wet weather do much damage and make the soil very difficult to work. Sheep are kept on almost all farms, but the attention bestowed on this description of stock appears quite subordinate to the growth of corn. The rock of the lower chalk, in some parts, assumes such a degree of hardness, that it is successfully quarried for architectural purposes. Thus the Tottenhoe stone is very useful and beautiful in the interior decoration of churches, but for exterior work it is liable to be affected by the weather. Being so hard, it is not useful for agricultural purposes, though its composition is very much like that of the upper chalk, which is extensively used as a mineral manure. In order to show how similar are the constituents, the following simple analyses of two pieces of chalk are given. Number 1 is a fragment of upper chalk taken from Hambleden, and which slakes like lime on exposure to the air; the other is from a pit near Bledlow, where it is used principally in the formation of bye-roads:—

No. 1.		No. 2.	
Carbonic acid	42	Carbonic acid	42
Lime	56	Lime	55
Oxide of iron, sand, and clay	2	Clay and sand	3
	100		100

Here a general analysis does not do much to account for the different degrees of hardness, but perhaps it shows that the lower chalk, if burned into lime, would make a very excellent manure. Now, although this formation is highly calcareous, some of its cultivated soils contain very little lime. But neither chalking it nor liming it is much attended to in Bucks; though the Hampshire men, who have a similar soil, and who are celebrated for growing excellent white wheat and fine straw, lime extensively. Indeed the malmy soils of this county show by analysis that they

require lime, and as lime possesses the property of decomposing the silicates of the soil, and thereby assists in the production of the soluble salts which are indispensable to vegetable life, it considerably abridges the necessity of fallowing. Almost all of the lower chalk is under the plough; it makes very indifferent pasture when laid down to grass, unless it is irrigated by some of the streams which rise at the foot of the hills. It is very difficult for a practical farmer, with only a limited knowledge of geology, to state whether there is any real development of the upper greensand in Bucks. An able geologist says, "the greensand is a compound as incongruous as the great image with its head of gold and feet of miry clay. The gault is, in one place, lost in the upper greensand; in another, the greensand is replaced by the gault; and in a third, both appear to merge into the lower chalk." No wonder then that un-scientific persons cannot with certainty indicate its position and limits. There are certainly, in some parts of the county, beds of an argillo-calcareous character, and into these beds the lower chalk seems to graduate by an almost insensible transition. The change, however, produces no marked difference in the character of the soil.

On leaving the lower chalk, the gault is first found *in sitû* at the bottom of Bledlow Field, and it stretches from thence, through Ilmer to Aston Sandford, forming a district two or three miles wide. It then passes south of Aylesbury, and running by Wingrave enters Bedfordshire a little below Leighton. The gault clay is of a greenish-grey aspect, which grows darker in the atmosphere, and it is mostly a thin cold soil, which, when wet, is as sticky as glue. It is a most expensive soil to cultivate as arable land, and instances of this occur too frequently in Bucks, where perhaps is some of the stiffest ploughing in England. Some soils in the parishes of Cheddington and Weston Turville, and again in Walton Field near Aylesbury, are adhesive and stubborn to the last degree. Such land would always pay much better in grass; and it is a happy feature of this part of the county that land will soon become a fair pasture, and even if laid down without any seeds, the natural grasses soon make their appearance. A rough analysis was made of some soil taken from Walton Field, with a view only of ascertaining the amount of clay which it contained. After being dried, the result showed 26 per cent. of impalpable clayey matter, and 58 of silica; the remaining 16 per cent. being composed of lime, iron, potash, &c. This shows what a very strong soil it is, for the proportion of alumina in the purest pipeclay rarely exceeds 36 per cent.

The iron or lower greensand enters Buckinghamshire on the north-east at Bow Brickhill, and from thence to Leighton Tunnel,

constitutes the principal masses of a well-defined range of hills resting on the Oxford clay. These hills are continued, in a south-west course, to Brill, but the range here is traversed and extensively broken by numerous broad valleys, and thus separated into insulated patches. Throughout that part of the county the Portland stone forms the central region of the hills, the ironsand being confined to the summit. In the valley or plain to the south of Aylesbury, which separates those hills from the chalk range, the mass of the lower greensand can be little seen. In most maps it is made to extend all over Cublington, Aston Abbotts, and Wing, to Bierton. It forms no prominent feature in any of these parishes, and only appears in thin veins of yellowish sand, or may be more generally discovered in the rich superficial deposits which cover the best pastures, and give a little friability to some of the arable land. A trace of it can be discovered at Kingsey and Towersey, but the geology of this tract is much concealed by the extensive débris of flint-gravel. The sand and sandstone, which are particularly well developed in the Leighton cutting of the North-Western Railway, are entirely silicious, and contain brown oxide of iron, so that the tract occupied by this formation strikes the eye by the reddish-brown nature of the soil. The sandstones are often formed of coarse conglomerates, and consist of granulated pebbles embedded in a ferruginous silicious cement. The sand and stone occasionally alternate with subordinate beds of clay, loam, and ochre, which latter was much dug at Brill, but the supply appears now quite exhausted. The soil is mostly a sandy loam, inclined to be weak, with patches of clayey loam, gravel, and peat; but all with fair farming produces good crops, and is mostly famous stock land. The lower greensand, at its conjunction with a more retentive stratum, throws up many springs, and the chalybeate spring at Dorton takes its rise in this formation.

The chalk and greensands which have been under consideration compose the first division of the secondary strata, called by geologists the cretaceous system; the rest that will be treated of belong to the oolitic or jurassic system.

Before arriving at the great clay district of Buckinghamshire the Portland or Aylesbury oolite claims our attention, and is perhaps the most interesting geological feature of the county. The first appearance of the Portland stone, on the Oxfordshire side, is at Towersey, and it is afterwards largely developed from Haddenham to Cuddington, and is found all over the high ground, which is traversed by the turnpike from Thame to Aylesbury. Beyond that town this southern vein wears out, and its place seems to be supplied by the ironsand, so that these

two porous strata, by the one leaving off when the other begins, form a tortuous belt which extends from Thame in a north-west direction for a distance of almost 30 miles. All the beds of this oolite, which is a loose granular limestone, are not of any great thickness, and have evidently three well-marked divisions. On the top is a soft white stone resembling chalk, which is chiefly used for lime; the next layer produces good building-stone; while the bed below contains numerous casts of shells which so injure the stone that it is used for coarser purposes. However, these divisions are not always in the above order; the second vein of stone at Brill is highly contorted, and is used for pitching; it hardens by exposure to the air, while the bottom layer is best adapted for building. The colour of the stone, which varies much, is due to the presence of iron. On all the insulated hills which are spread over the vale of Aylesbury, the Portland oolite is found near the summit. It rises through Long Crendon and Chilton, and culminates at Brill, where it attains its greatest elevation of 744 feet. In the elevated ground about Winchenden and Waddesden, and again at Whitchurch and North Marston, to a mile beyond Stewkley, it appears in detached masses. Not that the rock is ever of considerable thickness: the only spot of any great solidity is at Creslow, where it is 8 feet thick. On this the house is built, and the cellar, formerly the crypt, is hewn out of the solid rock. Whenever the stone appears in these broken portions it seldom presents any breadth of surface, being more frequently covered with other deposits. Thus at Crendon the stone is overlaid with a thin band of ferruginous stone, covered with a seam of the greensand, containing minute particles of ochre and finely granulated pebbles. Above this again is a deposit of the gault, which forms a stiff clay on the summit of the hills, and has a few rolled flints mixed in the upper soil. These flints having been transported and exposed for ages to the influence of the air and the percolation of water, are altered from black to brown, yellow, and red, which has led some to suppose them to be another sort of stone. The principal development of the Portland oolite, which commences at Scotsgrove, forms a tract of exceedingly useful arable land. It is a dry sandy loam, in some places light, in others more retentive, and very fertile—all capable of yielding excellent crops with good management. There are on it a few patches of peat, which vary from a few inches to several feet in thickness. At Stone, just above the rock, there is a good depth of pure sand which changes from yellow to quite white. It is a disputed point among geologists if this is a Wealden or an oolitic sand; however, it matters not on agricultural grounds, as it only crops out in small patches. The attempt to sink an Artesian well at the County

Lunatic Asylum, though it has failed to produce an adequate supply of water, is interesting in its geological results. The well in question is more than 550 feet deep. The first 20 feet were found to consist of limestone and yellow sand, and then, with the exception of a few narrow bands of limestone, there appeared a solid bed of clay more than 500 feet thick. At the distance of 530 feet from the surface the great oolite was found, and after sinking into that rock about 30 feet the present meagre supply of water is obtained. This proves the total absence of the Oxford oolite and calcareous grits.

We have now arrived at the grand feature of the county of Bucks, the Vale of Aylesbury. Much has been written and much more said about this celebrated tract of country, and truly on looking at it from Brill Hill at one extremity, or from Whitchurch on the other, it might be called a land flowing with milk and honey. There is a large district reaching from Aylesbury almost to Winslow, to various parts of which the rich title of the Vale of Aylesbury has been applied. Without wishing to be particular as to words, it might be said that the term *vale* could not properly be applied to any portion of the district. It might be described as an undulating plain, from which now and then rise patches of elevated land, which are mostly capped with the Portland stone before mentioned. The land on which it really rests is marked on the map as Kimmeridge clay, but again learned professors differ; for while Phillips and Conybeare say that there is no such clay in Bucks, and further assert that the *gryphæa dilatata*, the characteristic shell of the Oxford clay, has been traced to the very junction with the Portland stone at Waddesden Hill, Smith, the father of geologists, upholds the opinion first recorded. However, all parties agree that the Kimmeridge clay does not extend northward beyond the Vale of Aylesbury, and that the clay soils about Fenny Stratford are essentially Oxford clay. As farmers we can well afford to let this knotty point be settled by those capable of judging, for there are parts of the county where the gault, the Kimmeridge and Oxford clays, run into each other, and no practical valuer would discern the transition, or make a difference of 6*d*. an acre one way or the other. The real difference of the land does not depend on the peculiar clay stratum underlying it, but on the quality of the dark soil and rich vegetable mould which covers the clay. The Kimmeridge or Oaktree clay consists of beds of blue, slaty, or greyish clay, containing selenite. The Oxford or Church clay has beds of immense thickness of a tenacious and adhesive clay of a dark blue colour, which turn brown on exposure, and contain argillo-calcareous geodes and septaria, commonly called turtle-stones. There is not much to choose between these

two clays. Either in its purity would produce a wretchedly stubborn and barren soil; to the admixture of something less retentive and more fertile, we must look for the cause of increased productiveness. The real Vale of Aylesbury, the pastoral garden of the county, is not more than four or five miles wide. It may be said to include all that district, the exterior of which could be formed by the dotted line on the map, and runs through Aylesbury, Hartwell, Stone, Winchenden, Waddesden, Pitchcott, Dunton, Wing, Aston Abbotts, Bierton, and Broughton. There are numerous soils, of course, inclosed in this boundary; they vary much in a field, still more on a farm, and further still in a parish. The ground east of the turnpike-road at Weedon does not appear very excellent, while the ploughed land about Bierton does not present the idea that it is at all a nice soil to cultivate. The grass lands, too, vary much, some from having a depth of 2 feet of fine loam, to others which have hardly as many inches above the clay. The best of the land is devoted to grazing, while the middling and inferior qualities are used for dairying. There are other parishes besides those included exactly within the Vale, which have patches of very excellent land. Some first-rate grazing grounds are to be found at Chersley, Chilton, Dorton, and Brill. Still the far greater portion of these, and the similar good lands of Quainton on the west and Hoggeston on the north, are stocked with cows. There are general features about rich grazing lands which strike the eye of a stranger. They have a luxuriant and deep-coloured herbage, and mostly a gentle undulation, are raised rather above the level meadows, and wherever they are found there is a foot or two of rich earth incumbent on the clay subsoil. In some places this rich deposit is evidently the washings from the Portland oolite which occupies the higher ground; in some samples the small granulated pebbles of the lower greensand have been discovered, but more generally there is nothing for the geologist to show from what formations this valuable deposit is derived. When thus in doubt the sister science of chemistry may lend a helping hand, and in some measure account for the well-known fertility of the Vale of Aylesbury. For this purpose the following interesting and elaborate analysis was made by the Society's chemist. The soil was taken just below the turf from "the Park," a field of well-known fertility at Putlowes.

One hundred parts of the soil when dry contained—

Organic matter	16·10
Soluble in acids	26·79
Insoluble in acids	57·11
	100·00

Soluble in Acids.	
Silica	4·18
Oxide of iron	6·70
Alumina	1·21
Lime	5·97
Magnesia	0·44
Potass	1·15
Soda	1·64
Carbonic acid	3·29
Sulphuric acid	1·63
Phosphoric acid	0·58
	26·79

Insoluble in Acids.	
Silica	50·06
Alumina	4·41
Lime	0·57
Magnesia	1·08
Potass	0·99
	57·11

Nitrogen in the soil 0·460 per cent., equal to 0·560 ammonia. Of this nitrogen 0·0422 per cent. exists in the condition of salts of ammonia, the remainder 0·4178 being in the condition of nitrogenized organic matter.

The essential ingredients of a good soil seem to be abundantly present here; the proportion of organic matter (ammonia derivable from it) is large; phosphates, sulphates, carbonates, and the alkalies the same. Again, from the abundance of decaying roots, and the quantity of sand (about 44 per cent.), the soil would possess a good mechanical condition. The learned Professor says, "I should be inclined to look upon it as a soil in which the materials are well adjusted;" but adds, "whether the same composition might exist without fertility is another question." So chemistry is not very decided on the subject. Leaving the Vale of Aylesbury, and proceeding north, the Oxford clay spreads itself all over that unhappy portion of the county which lies within a line drawn through Buckingham, Stony Stratford, and Olney. It is a most expensive clay to cultivate, and is, therefore, chiefly in pasture. Some of these grass lands, dignified by courtesy with the name of pastures, grow nothing but rushes, and are decorated all over with tufts of hassock-grass and numberless ant-hills. The uniform character of the clay is somewhat broken by patches of the Lickey Hill gravel, and also near its junction with the great oolite by beds of brashy gravel, while about Whaddon Chase and Winslow the gravelly wreck of many strata, but especially of the lower greensand, forms a very different sort of soil. From Marsh Gibbon to Steeple Claydon and Winslow there is hardly anything but poor wet clays. Above the latter town the débris of the ironsand gives to the land a reddish tint, while from thence to Bletchley there are hills of sand and flats of miserable clay. The whole of this district is used for dairying.

The remainder of the land occupying the extreme northern limits of the county rests on the great oolite. This stratum, when viewed generally, is regarded as one great oolitic mass, but in Bucks the upper parts of this formation, forming the acclivity of the hills which rise from the valleys of the Oxford clay, are

generally either fossil or rubbly, and are much mixed with clay. North of Buckingham the common yellow tinge of the oolitic rock is changed for a blue colour, and some have a pasty look and dead white colour, not unlike chalk. It was probably the chalky appearance of this oolite, as well as the soft white rock of the Portland stone, which caused the mass of the different soils of the county in the last Report to be denoted chalk, where there could be no deposit of chalk within twenty miles of the spot. There is hardly any real development of the stonebrash in the county, but principally cornbrash and forest marble, which latter is worked at Olney, Newport, Thornton, and Buckingham. The top soil of the forest marble is mostly clay, and forms—about the Lillingstones and Stowe, for instance—an argillaceous, wet, tenacious, and calcareous soil. In the cornbrash the mixture of calcareous, argillaceous, and arenaceous beds is favourable to their agricultural quality. It is a stronger soil than the stonebrash, and is distinguished by the presence of timber and pasture beyond Olney. In the district about Cold Brayfield and Newton Blossomville, and again at Emberton, Newport, and Stanton Bury, there are extensive beds of fine gravel, which when sifted resembles sea-shore shingle. All along the junction of the two strata from Wolverton to Olney, are patches of very excellent land, and some meadows that border on the Ouse are of first-rate quality. Indeed some grazing-lands at Lavendon, and by the river at Tyringham, and again at Biddlesden in the north-west, are hardly inferior to any in the Vale of Aylesbury. Along parts of the Ouse the ground rises abruptly from the valley into the thin stonebrash of Newton-Underwood, and Cold Brayfield. The agriculture of this end of the county, like its southern portion, presents a pleasing appearance; but whether it is from proximity to the good farming of Bedfordshire, or the natural fertility of the soil, it is difficult for a hasty glance to determine. If one were in a condition to draw a conclusion from such a view, it might be said that a junction of the two, an improvable soil and an industrious tenantry, had combined to brighten the face of the country. With the exception of some insignificant patches of the lias clay, which are to be found in the meadows of Turweston and Westbury, the whole of the geological strata of Bucks have been now slightly reviewed.

Arable Districts.

In taking a general view of the management of the arable land throughout the county, it will again be necessary to treat of some of the districts separately. This must certainly be the case in relating an account of the various rotations of crops. Beginning once more at the south of the county, there are the sands, gravels,

and clay-loams which occupy the foot of the chalk district. Now, as a matter of course, the lighter soils of the plastic clay and the Thames gravel, which is composed of the silicious detritus of several formations, require a different style of cropping to the heavier loams. On these friable soils the four-course is most common, and the land seems well adapted for the Norfolk rotation. Some farmers who have their land in good condition, and others from more pressing reasons, take barley after wheat. On the good loams of this locality a very severe rotation is common, viz., 1 turnips, 2 oats, 3 clover, 4 wheat, 5 barley, 6 beans, and 7 wheat. It may be considered that with five corn crops in seven years it is impossible to keep the land clean or in good condition. This district possesses the advantage of being able to procure manure from London and from barracks and inns in the neighbourhood; and some of the lands cultivated in the above manner are in very excellent order. Without wishing to particularise any, a ride over the Chippenham Court Farm will at once convince the most inveterate stickler for the four-course that good crops and good husbandry may be attained under such a severe rotation. Great care and much expense are necessary to eradicate annuals and root weeds, and every string of couch that is left in the turnip-ground is forked out during the autumn. The clover, by coming but once in seven years, stands well, and oats and barley, after turnips and the wheat, are changed as the condition of the land and the wishes of the cultivator may require. Of course, this system would be very much improved by the omission of a second white-straw crop in the fifth year, for that is the chief, if not its only fault. If the rotation ended with the fifth year, then, indeed, the consecutive white-straw crops might do; but as two other corn crops are to follow, in the majority of instances this must be wrong. As it is, with good and clean farmers the system flourishes; but with less careful men it produces neither good crops nor clean land.

On the south side of the Chiltern district the land and the farming are both so inferior that it is very difficult to say what course of cropping is pursued. The four and five courses, or modifications of them, are most common, and sometimes grass seeds lie for a longer period than one year. On the elevated lands of the interior, and the gravelly soils which compose the narrow valleys of the chalks, it is too general to take turnips, barley or oats, seeds, wheat, and then barley. Now the land of this locality is not of first-rate quality, nor is the farming so superlatively high as to justify this extra whipping crop. The sheep form the principal stock, and are well fed and properly managed; but as little heavy stock is kept, the manure from the yards is of the most inferior description. On the lower chalk

and gault clay some of the farmers crop on the four-course or Norfolk system, some on the old rotation of two crops and a fallow, and some on no system at all. Since the time of the last Report, the cultivation of the land at the north base of the Chilterns has much improved, but there are some unhappy exceptions to this progression; and about the Risboroughs and Halton there are some farms in a similar condition to that in which they were fifty years ago.

The principal arable districts of the county are now gone over, and next comes the ploughed land in the Vale of Aylesbury, and the dairy-grounds of the north. In the districts already described, nine-tenths of the land are under the plough,—in the rest of the county not above one-fourth is arable; of course on grass farms the cultivation of the ploughed land is quite subservient to the pastures. The systems of farming are numberless, but, by taking the various description of soils, the general style of farming of each sort of land may be illustrated. The soils within ten miles of Aylesbury vary greatly, from a strong clay to a burning gravel; and the proportion of arable land also differs very widely—on some farms as much as half the land is under the plough, on others none at all. The loams and good turnip soils of course are mostly arable, and will be first considered. This description of land, of which the largest tract is found south-west of Aylesbury, is generally by good farmers cultivated under the four-course shift. For eight years the rotation would stand thus:—

1. Fallow and swedes.
2. Barley.
3. Clover.
4. Wheat.
5. Turnips after vetches or fallow.
6. Barley.
7. Beans with a heavy coating of dung.
8. Wheat.

On rubbly and gravelly soils the same course is pursued where the land is capable of carrying winter stock without injury; but if injury is likely to be produced either to the stock or the land, green crops, to be fed off in the summer months, are substituted, instead of root crops for winter feed. Stiff retentive clays, by the best agriculturists of Bucks, are, in their present undrained state, often cultivated under the three-course, viz.—1st, fallow, either a dead fallow, or vetches fed off; 2nd, wheat; and 3rd, beans; and begin again. Occasionally oats are sown upon a fallow, and then clover, which is followed by wheat, but more generally by beans first, as there is always a danger in losing the wheat-plant from slugs after clovers on stiff clays. Clover is never introduced oftener than once in eight years. There is a loose frothy descrip-

tion of clay, too loose to grow vetches to advantage: on such soils rape is substituted for vetches, and the cropping the same as before. On some of the dairy and grazing farms, where the arable land bears a very insignificant proportion to the grass, there corn is constantly grown, as straw is much in requisition, and manure is always to be had. Thus wheat, beans, barley or oats, and beans, succeed each other, and wheat begins again; though sometimes the beans are left out, and vetches fed off, or a root crop is grown instead.

On the great oolite, north of Buckingham, the four-course is prevalent, but as there is much grass-land, very little clover is grown, and beans are more general. Besides this rotation, on the same sort of land beyond Wolverton is the six-course: turnips, barley or oats, clover, wheat, beans, wheat; others have turnips, oats, clover, beans, wheat; or again, a five-course, turnips, oats, clover, wheat, and then barley or oats. These are the most general systems of cropping to be found in the county: there are numerous other varieties here and there, which, if recorded, would only tire the reader. Almost every existing course of cropping is to be seen in Bucks, and if some few of the peculiarities were confined within its limits, it would be greatly to the advantage of agriculture.

The fallow or root-crop being the commencement of all rotations, the preparation of the land during that year must first be considered. On some of the light loams in the south, a few swedes, but more especially turnips, are preceded by a green crop of rye or vetches, which is mostly fed off with sheep. Very few roots are grown on the ridge or baulk, almost all on the flat, principally drilled at distances varying from 14 to 22 inches. Ridging is mostly practised by landed proprietors and gentlemen. At Fawley Court the ridging system is seen in great perfection; but on those hot gravels and dry chalky banks one would imagine the flat a better way to keep out the summer's sun. This estate seems particularly unfortunate with regard to the introduction of excellent systems, which are not calculated for the soil or climate. In the last Report, the then proprietor had planted a colony of Northumberland tenants, who now exist only in name, and it requires no great foresight to predict that the baulking of turnips, and the house-feeding of sheep on such land will make but few converts in the neighbourhood. The Liverpool swede is most common throughout the county, though Laing's, Matson's, and other pretty varieties are extensively grown. In dry seasons like the last, such small sorts have not leaf enough to extract moisture from the atmosphere, and the Skirvings with their full foliage were consequently much heavier. Mangolds were not grown in 1809, and are not yet so much cultivated as they ought to be:

they are more often planted on the ridge; but one of the best fields in the county last year was on the flat, the ground being marked out both ways at 22 inches, and on the spot where the marks crossed the seed was set, and the roots could be horse-hoed both ways. There is much to commend in this practice. There is a saving of seed, and also of hand-hoeing, but 22 inches is too narrow for constant horse-hoeing, and 24 would be better. In the south of the county, most farmers grow from three to ten acres of this valuable root: the yellow globe seems the favourite. Crops of mangold, weighing 25 and even 30 tons, are frequently produced, but 16 tons per acre is a fair average for the swedes throughout the county. Farm-yard manure is mostly applied for all root crops; but in some parts of the county, where land is well dunged for wheat, turnips are grown without any further dressing. Indeed, one or two instances might be mentioned where the preparation and management of the root crop is most primitive. On a rough and half-cleaned fallow, in the month of June, some turnip-seed is sown broadcast, a single hand-hoeing constitutes the after-culture, and in the autumn some large weeds and small turnips form a scanty meal for a half-starved agistment flock. Happily this style of farming is rapidly on the decline, and though broadcast sowing is still in favour in the south, a proper cultivation of turnips is now looked upon as an essential requisite in all light-land farms. The occupiers of the thin chalks find that the less the land is stirred about in the spring, the better the turnips grow, and they also like the seed-bed to be tolerably firm. On the loams at Scotsgrove it is common to fold the sheep with short straw or caving scattered over the stubble-land during autumn. This is deeply ploughed in; sometimes the ground has farm-yard manure in the spring, but it always receives a dose of artificial manure when the swedes are sown. At Lillingstone the same sort of long manuring is practised, only the manure is brought from the stables of Buckingham, and strawed over the land, which is a clay loam. The ewes are then folded on it, and it is double-ploughed for the winter. The land receives but one ploughing in the spring, and roots are drilled with ashes without further dressing. Some other excellent modes of growing roots are occasionally practised in various parts of the county, but as they are general in other districts of the kingdom, it is not necessary to describe them here.

The common cultivation of naked fallows may not be so generally known. All the clay soils lie in large round lands or ridges, from 8 to 12 yards wide, with height varying from 18 inches to 4 feet. This excessive height precludes the possibility of properly cross-ploughing, and consequently the land is mostly turned backwards and forwards by the plough in the same direc-

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tion. The Rev. St. John Priest, in his last Report, being a Norfolk man, felt particularly disgusted that fallows were not ploughed "over wart" or across. He also seemed greatly to disapprove of the rough state in which the fallows were left, and strongly recommends the more frequent use of the harrow and roll. Now, for the purpose of extracting couch of course the soil must be thoroughly pulverised, but for the common purposes of fallowing, or resting the land, the Bucks farmers prefer a rough to a fine tilth. It is still the incorrigible practice, in some parts of the county, not to give the fallows the first ploughing till the month of May, by which time the couch and other weeds have taken deep and entire possession of the land, and the ploughing is frequently a work of great difficulty. The tearing up such land in dry weather at this season is thought to do it immense good, but greater good would result had the land been ploughed in the autumn and exposed, in a rough state, to the winter's frost.

All soils are formed by the disintegration of rocks and minerals, and as decomposition takes place slowly in clay soils, such lands often require a fallow to reduce the soil to a texture in which, by its solubility and other properties, it can sustain the life of plants. A succession of corn crops exhausts the available matters; a fresh portion of the soil is acted upon and rendered soluble during the year's fallow by atmospheric action. The larger and more varied the surface to be acted on, the quicker will the chemical changes proceed; so that repeated ploughings are not so beneficial in really loosening the soil as in extending the surface, and by division and comminution of the masses giving access to the sun, air, and rain. Such, then, is the theory of fallows, but in practice it is often found that the necessity of fallows proceeds more from the foulness of the land than from its positive barrenness. Then, as the objects of fallowing—whether to restore fertility or to kill weeds—are both enhanced by early ploughing, it is hoped the absurdity of postponing that operation till the spring will soon be exploded. The common practice now in Bucks is to plough the fallows three times, seldom harrowing them, and now and then running the grubber across. Farmers contend, and with good reason, that if the land is made fine, a dash of rain causes it to run together and excludes the air, whereas if left moderately rough the rain passes between the clods, and the atmosphere still finds admittance to the soil. Provided the couch can be effectually eradicated by these means, and in dry seasons it certainly is destroyed, Mr. Priest's severe remarks are not altogether merited; for as his Norfolk gravels, and indeed the light chalks of this county, require the drought to be kept out, on stiff clays the freer the access of the sun's rays

the better. Sometimes during the summer or autumn the land in fallow is manured with long dung from the farmyard, and, after it is ridged up, the wheat is sown, mostly broadcast, in the month of October. Vetches are planted in the autumn or spring, commonly after one ploughing, the land being cleaned and fallowed after the crop is fed off. Rape, mustard, &c., are sown during the summer on fallow land that is intended for wheat. Mustard is also grown in the south of the county on wheat or bean stubbles, and fed off or ploughed in to enrich the succeeding crop.

The root crop is succeeded by oats or barley; but little turnip land is sown with wheat. The preparation for Lent corn consists of one or two ploughings, more frequently one, with a scarifying. The season for sowing varies with the weather, the situation, and the condition of the land. March and April are the busy months, but late oats are sown in May. Comparatively little barley is grown north of the Chilterns. About Slough winter oats are sown with much success, and crops, which usually vary from 6 to 8 quarters, have in more than one instance reached as high as 14 quarters per acre. Winter oats are the best grain to sow on land in very high condition, as too large a crop is never grown. Lillingstone Lovell was the only spot last year where winter barley was observed, and the crop was stated to yield 12 quarters per acre. The grain was very inferior and coarse, but it was boiled and given to the pigs in milk, who appeared to thrive remarkably well on it. The average yield of Dutch oats throughout the county may be taken at 6 quarters; tartars yield from 4 to 8 bushels more. The barley crop on the Chilterns is commonly 4 quarters: on the better lands of the county an average of 5 quarters is obtained.

On a good portion of the ploughed land but little clover is grown, and on clay and loamy soils it is commonly sown alone. On the chalk hills it is invariably mixed with white clover, trefoil, and ryegrass; for, as hardly any beans are grown there, the frequent repetition of clover makes the land very tired of it. Red clovers are often mown twice, and some assert that better wheats are so obtained than if the aftermath is fed off. This is explained by saying that the higher the clover grows the larger are the roots, and that these fine roots nourish the young wheats. It may be so, if clover after being cut the first time is constantly gnawed so close that it never flourishes; but if clover is allowed to grow up, and just before blossoming is properly hurdled off with sheep, there cannot be any great difference between its being severed by a scythe or a sheep's tooth, and the dressing left must be very beneficial to the following wheat. There are very many instances in which it would be most judicious to mow

clover a second time, and the practice is in no way condemned, as a supply of winter provender in the shape of hay is essential. An average crop of the artificial grasses may be 25 cwt. on the Chiltern Hills, and it increases from that quantity to 2 tons of clover hay per acre, which is produced on the very best lands. Ryegrass is grown on peaty and fresh broken grounds; it is considered bad for clay soils. Sainfoin will grow almost all over the chalk district, and on the stone-brash of the north. Its cultivation is more common than it was in 1809, and yet not half so general as it might be; and though some good farmers make it a part of their rotation, there are many poor farms with calcareous subsoils where not an acre is seen. On the Chiltern range many steep and chalky banks which, with expensive tillage, yield meagre crops, would under sainfoin produce lots of hay and sheep-keep at very little cost. Sainfoin was formerly kept down eight or ten years; now the usual term seldom exceeds three or four years.

The clover-ley is usually ploughed but once for wheat, though in some instances on heavy lands, directly the first cut is removed, it is broken up for a bastard fallow. This is a very good plan where land is foul or subject to the ravages of the slug. Some bean stubbles are prepared for wheat by being simply skimmed or pared. A good portion of the wheat on the hilly and retentive soils is still sown broad-cast, but in the north and south drilling is general. There are a few dibbling machines which do their work well and give great satisfaction. They generally dibble five or six pecks of wheat, and the parties who possess these implements also plant most of their spring corn with them. The quantity of seed wheat depends on the land, the season, and the mode of sowing. When land is in good heart, one bushel by some is considered sufficient in October, but on wet and poor land seldom less than two bushels is planted. On sandy and light gravelly soils it is found a good plan to fold the land after the wheat is planted, and before it is up; and on moist soils solidity of the flag is obtained by clod-crushers and wheel-pressers. The season of wheat-sowing is much later than it was in 1809; then, on the elevated part of the chalk hills, wheat was sown before the old crop was reaped. Now, in the uphill country, they begin in September, and in other parts of the county the planting is extended to the middle of November. The south of the county is celebrated for producing some splendid samples of Chidham wheat; but like all fine wheats it is a shy yielder, and much of the Barwell-red and similar wheats are grown instead. On the light lands of the other parts of Bucks the Spalding and red Lammas are mostly grown, while on the clays the Hopetoun and old Suffolk appear favourite white varieties. The yield of wheat on good clays and mixed loams is considered

to average 4 quarters; on the cold wet clays and on the Chiltern Hills 3 quarters per acre would be a fair crop. The average yield of wheat in the county in the last Report was stated to be nearly 25 bushels; barley 37½, and oats about 33 bushels per acre. The produce of beans was calculated at 3 quarters. Wheat hoeing is not very common. It costs by hand from 2*s.* 6*d.* to 4*s.* per acre, but when wheat is widely dibbled or drilled, it can be horse-hoed well for much less than 1*s.*, as a man, boy, and one horse can do 8 acres in the day.

Winter beans are now extensively planted wherever leguminous crops are grown. When beans are sown in the spring they are frequently mixed with peas, and vetches too are often grown in conjunction with beans. The Cotswold peas and white-eyed beans produce the finest crops of pulse; the proportion of the seeds being 1 bushel of peas to 3 of beans. When mixed with vetches it is common to sow 2½ or 3 bushels of winter beans and 1 peck of vetches to the acre; the produce of such a mixture this good year has been 4 quarters of beans and 1 quarter of vetches. Not many peas are grown alone, but Marlow is celebrated for the production of green peas for the London market. The pea principally planted is the Early Warwick, which is first sown in November, and sold to the hawkers in the summer from 8*l.* to 12*l.* per acre. These men send the green peas to town, and agree to clear the field in a given time in order that the land may be sown with turnips. The quick gravels which here border the Thames are remarkably early in the spring, but as it is only the first crop of peas that is very profitable, a great extent is not grown. Such is the rapidity of vegetation on this soil that peas, turnips, and wheat, are sometimes planted on the same ground in the course of twelve months. Beans on stiff retentive soils are still hand-dibbled across the ridges, but on the flat lands they are drilled at wide intervals and well horse-hoed. Winter beans are the most certain croppers, but do not perhaps yield so much as the spring sorts. The bean crop frequently varies from 2 to 5 quarters, and the medium quantity of 3½ quarters will perhaps represent the average yield of the county.

In the only two instances where flax was lately grown there was the usual difficulty in finding a market for the straw. This appears remarkable, especially now dressed flax commands such a high price in our markets. Cabbages, carrots, and potatoes are grown only in small patches, and the cultivation of the latter root is even proscribed by some agreements. Towards the south are some kitchen-gardens and large cherry-orchards. The water from the chalk hills being impregnated with carbonate of lime is well adapted for the growth of water-cresses, large beds of which are cultivated for Covent-Garden market.

Grass Land.

Without any reliable source of information as to the proportions of grass and arable land, it has been calculated, apparently with much justice, that four-tenths of the available land of Buckinghamshire are in pasture. The grass-lands of the county may be divided into three heads: the rich grazing-lands of the Vale of Aylesbury; the greater extent of dairy-land, which includes the cold clay pastures of the north; and the alluvial meadows that border the various streams which water the county. The fertile pastures in the neighbourhood of Aylesbury, whose celebrity has been already noticed, are principally devoted to the grazing of cattle, but there are numerous patches of land included within the Vale which are not sufficiently good for feeding cattle, and these are devoted to dairying. As a rule, these best lands are never mown; but the meadows by the river-side, which are liable to be flooded, are saved for hay. On the dairy-grounds it is common to keep some grass for feeding, and other lands are constantly mown, being, of course, supplied with some farm-yard manure, compost, or other dressing. Some farmers like to vary this, and mow one ground one year and feed it the next. This appears the most natural way of treating pastures, yet there are some which would be greatly injured by being mown, while there are a few meadows now mown which deteriorate by being fed. Haymaking is well understood in Bucks, and the amount of labour expended on it in the Vale costs generally 10*s*. or 12*s*. per acre. Tedding-machines are common, and great care is taken, by constantly keeping it in cocks, to preserve its green colour. The produce of the best land may average 2 tons of hay per acre; other pastures much less, till it dwindles down to 15 cwt., which is the usual crop of the worst meadows of the Oxford clay. The hay from some of the best meadows is of very excellent quality, and will alone fatten an ox; its peculiar clammy touch and exquisite perfume will at once test its goodness. Little of this superfine hay is sold, but a great deal from the other meadows is sent to London, as well as most of the clover hay. Indeed, the quantity of hay that goes from the Vale, and the little manure that is imported, speaks more for the natural fertility of the soil than it does for the high state of its agriculture. The meadows which border the Thames in the south of the county produce a fine quick herbage, and mow very excellent hay. These lands are not subject to summer floods, and, having a gravelly subsoil, are nicely dry in winter, when the water is moderately low. Quick winter-floods do much good, and the high level of the river is much advantage to these light-land meadows in summer. The Thame stream, which runs through the Vale of Aylesbury,

is getting from bad to worse every year; in some places the bed of the river is entirely silted up, and, in addition to the other evils, that new pest of our rivers, the *Anacharis alsinastrum*, has found its way into all the branches and dykes of the Thame. In the summer of 1853, large quantities of hay, so valuable in this district, were spoiled, flooded, or washed clean away. There appears to be no system whatever of keeping up the banks, clearing the stream of obstructions, and cutting the weeds. If all this was properly attended to, the millers would have a more regular supply of water, and summer floods would cease. As it is, the least excess of rain in a wet summer season sends the water from the narrow, irregular, and partially blocked-up channel, over the adjoining meadows, to the serious injury or total destruction of the grass-crop. The same remarks apply, in a less degree, to the Ouse. No care is taken to confine the water within the river-banks, or to free the land rapidly from floods. The dykes are seldom properly trimmed or scoured, and in the neighbourhood of Olney are so grown up that cattle can easily ford them, and pass from one meadow to another. The little river Ray, which derives its supply of water mainly from land-springs or surface-water, in the winter of 1853 flooded the neighbouring Otmoor country for nearly six months. During the last summer it was, in parts, perfectly dry, and cattle which pastured on its banks had to be watered at a very considerable distance.

Grazing.—The cattle that are grazed in the Vale of Aylesbury are mostly Herefords. There are several very fine Devons, and likewise some good shorthorns. There may be other grass-lands which may fatten faster than the best pastures of the Vale, but there are no meadows in the kingdom which can so perfectly develop and mature a large ox. It is common for the grazier to purchase his stock in the spring, and to dispose of them from July to October, while a few are stalled for six or eight weeks before Christmas. Some cattle are bought in the autumn or winter to feed off the rough grass from the pastures, but, as few of the best grass-lands will bear treading, they are kept clear of heavy stock from November to May; and, if store-cattle are then in hand, they are fed in yards with a varying allowance of hay. The number of graziers in Bucks seems to be constantly changing. One man may be tired of feeding, and resolves to try dairying; while his neighbour, being less pleased with the manufacture of butter, determines to embark in grazing. There are other farmers who have a herd of milch cows and of grazing cattle, and they regulate the proportion of these stock according to the price of beef and butter. Of course, there is no great extent of such land where a farmer can graze or dairy as he thinks best; the far larger extent

will not feed, and again, there is some land much too good for the profitable production of milk. The quantity of really good feeding-land throughout the county, does not exceed 8000 or 10,000 acres. There are many good grazing farms within a few miles of Aylesbury where the quality of the land and the selection and management of the stock are alike excellent. There are many patches of land better, and perhaps some whole farms may be as productive, as Creslow, Pultowes, and Broughton, but none are more celebrated or worthy of notice, and these are selected as good specimens of their class.

A visit to Creslow on a summer's day seldom fails to prove a rich treat. To the agriculturist, the number, magnificence, and superb condition of the stock, the boundless extent of the inclosures, the luxuriance of the herbage, and the able management of the whole farm, form subjects of wonder and admiration; while the general observer cannot fail to be pleased with the beauty of the pastoral landscape, the splendour of the wild flowers, and the mediæval relics of the interesting old mansion. Even in a blustering, drenching day in last October, a peep in the farm well repaid the cost of a long journey, and a generous hospitality made ample reparation for the inclemency of the elements. This farm has long been celebrated in the annals of grazing for the wonderful animals which have been fed on it. In the days of the great war the late occupier at different times sold 20 Christmas oxen for the enormous sum of 2123*l.*, which is an average of 106*l.* 6*s.* for each bullock, a price probably never before or since realized by any one grazier. And the present worthy tenant, though he does not attain the notoriety which followed his late relative and predecessor, still furnishes a constant supply of useful animals, of which the splendid Cotswold ewes at the last great Christmas market were very fair specimens. Creslow is a farm of 860 acres, but with additions the occupation now amounts to 1100. The common stock of this farm is 500 cattle, and in the winter 700 ewes: in grassy seasons, after the ewes are gone, sheep are bought, to come out at Christmas. The house and premises are situated on a hill, the top of which is formed of the Portland oolite, and the base of Kimmeridge clay. One grazing field, perhaps the largest inclosure of really good ground in the kingdom, contains by admeasurement no less than 323A. 3R. 2P., a pretty little farm in itself. This field consists of a series of hill and dale, and consequently the soil varies much in quality. Where the stone and clay join, the water, which filtered through the stone, is thrown out by the clay; and here draining is necessary, which is principally done with turf. The main drains, which have pipes, open at intervals into little stone cisterns for watering the cattle. The

summer stock for this field is 220 bullocks, and 200 ewes with their lambs, generally here called "couples." It is very curious to observe the cattle and sheep over this large inclosure. Herds of cattle and flocks of ewes, which are purchased from different fairs, locate themselves in different parts of the field, retain their old companionship, and seldom trespass on their neighbours' domain, or stray away from their own part of the ground. The greater number of the oxen are Herefords, some Devons, and late in the year a few Highland Scots. In consequence of the protracted drought last summer, the grass at Creslow was unusually short, and the stock did not make anything like their usual progress. This farm possesses the advantage of having about 100 acres of it arable, which enables straw and roots to be grown for the winter's stock. In the fall of the year, before the cattle are tied up, they are supplied with hay in racks, which are placed round the ricks in the field. The sheds before Christmas were well filled with 50 Hereford oxen, which were receiving hay, a bushel of sliced swedes, and 3 or 4 cakes (of 3 lbs. each) daily.

The grazing land at Putlowes, though of less extent than that of Creslow, is decidedly of superior quality, and presents that true feature of the feeding district—a rich, deep loam, resting on a strong clay. It is really wonderful to see the size and fatness of some of the cattle here. In last October there were in one field 20 splendid oxen, weighing 160 stone (8 lbs.) each, not one of which had received hay or oil-cake. Now, in selecting these animals, care must be taken to choose those which show an aptitude to fatten and have sufficient age to accumulate flesh quickly. This most successful grazier, in common with all those who are engaged in feeding cattle, is sadly puzzled to find oxen of a proper age to feed; for, while lots of fleshy steers are to be had everywhere, great good bullocks are not to be found, and the steers will not increase in weight and value in a given time, like the 4-year-old oxen. Large grazing fields appear to be liked, if the land is really good and water plentiful. At Putlowes there is a ground of very excellent quality, containing 98 acres. The usual stock for such land is a bullock to an acre, but sheep are generally kept in addition, to the extent of one fat sheep, or one couple (ewe and lamb), to each ox. The cattle which are not disposed of from grass are perhaps supplied with a little hay in the pastures before they are tied up. They are stalled for about two months, and fed on hay and oil-cake. The quantity of cake given to these large cattle is really wonderful, 6 cakes or 18 lbs. per day being a common allowance, and some instances have occurred in which an ox has eaten *fifteen cakes* per day. This is surely more than the stomach of any bullock can profitably assimilate. Putlowes has long been extensively known for its

Christmas beef. This year a stall of 40 very superior Herefords and shorthorns realised on an average more than 40*l.* per head.

At Broughton House the stock has lately been confined exclusively to Devons. This farm lies about one mile south of Aylesbury, on the Tring road; and, as the Portland stone is clearly seen in the garden allotments by the tollgate, it must of necessity follow that this superior grazing land is on the gault clay. This confirms the remark that was made in describing the geology, that the fertility of the land did not depend so much on what clay it rested, as on the quality and depth of the top soil. There are two or three fields at Broughton House as good as any in the county; but there are some, where the deposit of mould is not so deep, which are only of a second-rate description. The farm contains about 200 acres, 56 of which are mown. There is no ploughed land, so the litter for the stalled cattle is purchased. There were last autumn 36 very fine Devons, good fleshy animals, but not possessing the touch or fatness of those at Putlowes. These cattle had each half a truss of hay and 6 linseed cakes in the day.

The stock and farms of three of the most celebrated graziers having been described, it would be uninteresting to particularise more. The amount of stock kept varies with the size of the cattle, and more particularly with the quality of the land. The instances which have been produced are from the best localities. In a northern district, an inclosure of 54 acres had a herd of 40 cattle; a 16-acre field, nearer Thame, had 12 beasts and 16 couples; and on another good farm the summer stock was 2 100-stone beasts and 2 couples to 3 acres. It is necessary that the summer grazier should have a thorough knowledge of the capabilities of the ground, that he should be under rather than over stocked, have a good judgment in buying and selling out, and give constant care and attention to the comfort, health, temper, and progression of the stock; these rules are not confined to Buckinghamshire, but are essential to all profitable grazing. On the second-class grazing land, not quite good enough for fattening oxen, a great many barren cows are fed. These cows, which are all shorthorns, are bought from the dairyman, or the strawyards of the arable farmers, in the spring, and sold during the summer and early autumn. The fat cows are generally disposed of to the country butchers, while the steer-beef principally goes to Smithfield, where, from July to Christmas, the Bucks cattle furnish a considerable contribution towards the required supply, coming in when the stall-fed cattle of the Eastern counties do not appear. There is generally quite a clearance with the Buckinghamshire summer graziers at the great Christmas market, for after that hardly a fat bullock is to be found in the county.

The preceding remarks apply exclusively to the beef produced on the grass lands; regular stall feeding forms but a very small item in Bucks farming. There are some gentlemen, and a few enterprising tenant-farmers, who graze largely in the winter. The most extensive stall feeding is to be seen at Fawley Court, where there is a magnificent shed, capable of containing 140 head of cattle. This shed is particularly deserving of notice. A roof with three spans covers the whole building, and the cattle are ranged in double rows, with passages between them. In the one, at the head of the cattle is a tramway, and a truck containing the food is' pushed along it. Each pair of bullocks is stalled off, every ox has a separate manger, and there are troughs for the water, which is pumped in by the steam-engine. Last autumn this splendid apartment—it really is no shed—was not full, but 90 superb Hereford oxen were stalled. They were then being fed on swedes, hay-chaff, and barley-meal. The turnips were grated quite small, and mixed with the other food, and so given to the cattle. When oilcake is used, it is ground and steamed, and then mixed in like manner. At Latimer there are some excellent steers, which evidently, like those at Fawley, were the produce of Hereford fair. Some of these were stalled, some grazed in open yards, and all fed on sliced swedes, meal, and hay. At Snelson farm beyond Olney, and again at Shardeloes to the south, and in many other spots, were several good lots of cattle; but winter grazing is the exception, not the rule, in Bucks.

There are many herds of pedigree shorthorns in the county: at Wiltons Park are some first-rate animals; and at Shardeloes and Missenden Abbey there are also dairies of very excellent cows. There was formerly a celebrated herd at Latimer, but it has very much deteriorated of late by the large admixture of Alderney blood. Passing to the borders of Bedfordshire there are some very useful cows at Southcott; and those at Claydon House are particularly deserving of commendation. The gigantic ox, which attracted so much attention at the Smithfield Show in 1853, was the produce of this herd. But no stock, as to numbers and purity, can be compared to those at Lillingstone Lovell, where are some truly magnificent animals. Here, and at all the herds mentioned, numerous calves are reared; and there is an annual sale of stock at Lillingstone, and also at Latimer. It is a pity that the former herd is not more extensively shown, for almost in every instance in which they have been exhibited they have been successful. The superb yearling bull, which carried off the Society's prize at the Norwich Meeting, was bred at Lillingstone.

Butter.—Buckinghamshire is certainly the greatest butter producing county of England, and the number of cows kept within its

limits is very considerable. The grazing land is confined to certain localities, but dairying extends over a much larger area. There is an excellent dairy of superb Alderneys at Little Horwood, but the cows principally kept are the shorthorns; and Bucks may freely challenge any county south of the Trent to produce a more extensive or better assortment of milch cows; they are well bred, have large frames, and are excellent milkers. The credit of breeding these useful animals does not belong to the county, as they are mostly imported as 3-year old heifers from Yorkshire and Lincolnshire. But few are reared in Bucks; some of the cow-calves may be weaned by the arable farmers and on the third-rate pastures of the north. A lot of 70 or 80 were reared the year before last at Aston Abbotts; but the dairyman mostly buys in his stock, and, after milking them for three or four years, tries to dispose of them for London cows. There is always a ready sale for these animals at high prices; and provided a cow has a great frame, a large forward udder, and the appearance of being a good milker, she is quickly bought up by the dealers. When they are springing for calving they will commonly fetch from 18*l.* to 20 guineas each. Of course this pays well enough, but comparatively few are sufficiently good for the London men; and, independently of losses, so many turn barren, that the difference between the buying-in and selling-out price is frequently on the losing side. About three acres of good dairy land will keep a cow the twelve months. As an instance of the quantity of stock kept on a dairy farm, the occupier of 300 acres of second-rate grass land has, during the summer, 80 or 90 cows, and 100 couples: 120 acres are mown for hay. The dairyman tries to reduce his stock for the winter, and so sells off his London, barren, and useless cows in the fall of the year. The dry cows do not get much hay, but a cow in milk during the winter will eat two tons, and the addition of one oilcake per day is found to be well-spent money. Most frequently the milch cows subsist entirely on hay, and are seldom supplied with roots or any artificial food. In one or two instances, where cows have been fed on swedes, the judicious admixture of saltpetre has appeared to remove the unpleasant flavour of the butter, for it has made in London quite as much as some from adjoining dairies, where the cows were restricted exclusively to hay. It is best to give the roots directly after the cows are milked. When the hay is at all damaged, and indeed in all seasons when the price of butter is at all remunerative, giving cows a few mangolds, and even turnips and cabbages, or a little oilcake, meal, and grains, pays by the increased produce, besides improving the condition of the cows and the quality of the manure. The management of the dairy is well understood; and though conducted in a clean and economi-

cal way, it has nothing in it that requires a lengthened notice. The larger dairies are generally more profitable, and produce more butter per cow than the smaller ones. The dairies of Littlecote, Nalduck, Cublington, Barston, and Little Horwood, are extensive and excellently managed; the last, which supplies butter to Royalty, is quite above commendation. The cows are milked by men, and the dairies mostly face the north, and are protected at the sides from the effects of the morning and evening sun by trees or shrubs. Thatch is considered the best covering for a dairy, as it is cool in summer and warm in winter. Some dairies are supplied with flues for raising the temperature in frosty weather, while the floors of some are sunk, with the idea of making them cooler in summer. It is common to churn twice a week, and all large dairies have a horse-churn, which holds 100 lbs. of butter and upwards. The butter is taken from the farmer's house by carriers, who convey it by rail to town. The carrier finds hampers and cloths, and the cost of carrying and selling is 11*d.* per dozen pounds. The butter is highly prized in London, and, from its good make and excellent flavour, it well merits the favour it enjoys. The average amount of butter which a cow produces is 5 lbs. a week, for nine months in the year. The calves are mostly sold when a few days old: the prices vary from 15*s.*, for ordinary bull-calves, to 40*s.*, which is readily paid for the best heifers. No cheese is made, and comparatively few calves are fatted for veal. An intelligent correspondent, whose extensive business and practical knowledge would render him a good judge of the subject, considers there are 120,000 acres in Bucks devoted to dairying. With the assistance of the arable land, and independently of the sheep kept on such grass grounds, 30,000 cows are dairied; and supposing each cow to produce 200 lbs. of butter in 40 weeks, the annual amount of butter for the county would be almost 2680 tons.

Sheep.—On the pastures throughout the county it is common to keep some sheep. On the grazing and dairy lands these are generally ewes, with their fat lambs. The ewes are purchased during the autumn, being rammed early in the season. All sorts of ewes are to be found, from the gigantic Cotswold to the tiny Welsh. Perhaps there are more half-breds than anything else; but also many long-wools and heavy downs. However thorough-bred the dam, the produce is seldom so, for while cross-breds have a similar ram, the Cotswold ewes are put to a down or half-bred, and the downs to a long-woolled sheep. It is the principal object to obtain size and a readiness to fatten, with a grey downy-looking face. The ewes are placed at once on the pastures, and seldom want anything but grass, except during severe weather, when they are supplied with hay. They drop their lambs through January

and February, and early in March, and some of the very early ones are supplied with split beans or white peas, while later lambs feed solely on the rich herbage of the pastures. As soon as the house-fed and early lambs of the arable lands are over, then these are sent to market. The Buckinghamshire lambs seldom come out much before May; but during that and the two succeeding months supply London with an immense quantity of that delicate meat. The lambs are generally cleared off by August, when the ewes having lost their offspring, readily fatten and are disposed of during the autumn. The usual proportion of sheep on grass is one fat wether or couple to an ox or cow. It is the almost universal rule to clear off the ewes every year and have a fresh supply; for, in addition to the ewes being good mutton, a large portion of the best land in some years rots sheep, and they could not be safely kept two years in succession. The season of 1853 was, in this respect, particularly disastrous, for many of the ewes, purchased early in the autumn, had to be sold off before they lambed, and all those which were unfortunately saved for another year were completely rotten. Indeed the ravages caused by rot are still to be met with in all parts of the county; the white fleeces and bottled throats of many sheep plainly indicate their unsoundness. The other class of sheep kept on the grazing lands are wethers. These are bought in the spring, either in their coats or just shorn, and are fatted during the summer. By October they are cleared off; but a few of the most superior are kept till Christmas. On the Chiltern hills and in the south the sheep fed are chiefly downs. These wethers, as lambs or shearlings, are imported from Berkshire and Hampshire, and being well fed on roots, hay and corn, or cake, during the winter months, furnish Smithfield with some very superior mutton. A marked improvement in the management and feeding of sheep on arable land has taken place within the last few years. The old Report mentions sheep, four years old, weighing but 20 lbs. per quarter, a weight now often produced in about a fourth of the time. Artificial food was then seldom given, and the number of sheep on the arable land was quite insignificant. Now it is common to keep one sheep to the acre, while the stock of some good arable farmers is considerably more. Where there are commons or sheep-walks on the hills, ewes are kept and the lambs stored; they are sold off or fed on the farm the following winter. These ewes, as well as those kept on the northern foot of the Chilterns, are Hampshire downs or half-breds; but there is a very superior and extensive flock of Southdowns at Shardeloes, and another of the most exquisite quality at Latimer. From what has been said it will be seen, as with cattle so with sheep, Bucks is essentially a grazing, not a breeding county. The ewes that are purchased for the grass

lands are invariably full-mouthed; the Cotswold and cross-bred sheep are drafted from the flocks of Gloucestershire and Oxfordshire, whereas the supply of short-woolled ewes is derived almost exclusively from the Western downs. The pure Southdowns are not often met with in the good pastures, as their superior quality does not make amends for smallness of size. It seems to be the land for heavy sheep and cattle; and Southdowns and Scots, though highly prized on poorer soils, are not much appreciated in the Vale of Aylesbury.

A large quantity of pork is made in Bucks. The *pigs* are mostly of the Berkshire breed, and, as observed in a former Report, are often bred in that county, stored in Oxfordshire, and fed in Bucks. Almost the entire refuse of the dairy goes to pigs. Twenty cows will afford enough flat milk for ten bacons and fifteen porkers in the year. In summer when the milk, on account of the weather, often contains much butter, pigs are fatted on milk alone. At this season they are usually made out as porkers, and weigh from three to four scores of 20 lbs. For this pork the small white breeds are preferred, as their flesh is delicately white, and they fatten rapidly. Throughout the county, but principally among the gentry, stocks of splendid white pigs are kept, and a good many pigs also are bred on the arable lands of the south of Bucks. Bacons—larger pigs, weighing from ten to twelve scores—are generally fattened in the winter, and in addition to milk receive an allowance of beans or corn meal. When slaughtered, it is common to singe the large bacon pigs; but porkers are always scalded. The burning may be best for the bacon; but the pigs always weigh lighter. In addition to the pigs thus fed from the dairies, some are fatted by arable farmers. At Scotsgrove, from July 1853 to March 1854, nearly 2000*l.* worth of pork was sold. These pigs are at first fed on boiled swedes and pulse (beans and peas), and are finished off with barley-meal. The corn is best boiled some days beforehand and permitted to become sour, and is then mixed with the fresh-cooked warm roots. These pigs seldom leave any profit for their keep in the meat alone; but the manure, which is very valuable, is carefully collected and applied with much success for root crops. There are many pigs fatted at Fawley and Latimer, principally on barley-meal, while those at Lillingstone have boiled corn and milk, and are disposed of as porkers at the Buckingham monthly fairs.

No view of the domestic agriculture of the county would be complete without a few remarks on the *Aylesbury ducks.* These ducks are perfectly white, and are kept in immense numbers in the neighbourhood of that town. When highly fed, they begin to lay about Christmas, and as all the eggs are hatched under hens, the old ducks are not permitted to sit, but continue laying during the

season. The ducklings are taken from their foster-mother the moment they leave the shell, and the poor hen continues her period of incubation till she can endure it no longer, and then leaves the nest a perfect skeleton, without the satisfaction of rearing a brood. The ducklings are kept in lots, warmly housed, and allowed but a limited access to water. They are fed, in addition to corn, with greaves, liver, flesh, and almost every description of animal garbage. In eight or ten weeks the ducks are killed and forwarded to London, where, in the early season, prices sometimes range as high as 14*s.* per couple. Of the numbers thus produced it is impossible to speak with certainty; but to illustrate the quantity, it may be stated that a little farmer at Bierton had at *one time*, last season, nearly 2000. From evidence given before the Aylesbury Railway Committee, it appeared that the enormous number of 800,000 were annually reared in the county; but this perhaps is the language of an ardent witness, and half that quantity would be nearer the truth. Nothing worthy of notice appears in the other fowls. The Cochin Chinas having originated and flourished through the poultry mania, are now properly valued as excellent layers, and are used as cross-breeds to improve the size, but not the elegance, of the common barn-door fowl.

The *cart-horses* of the county are heavy, dull animals, with long manes and tails and very hairy legs. The pace at which four or five of these great creatures crawl along in a plough would not say much for their agility and power, for they hardly ever plough an acre a day, and each horse has seldom more than 6 or 7 cwt. to draw. The clay-lands of the county require a great amount of strength to work them, and if a good supply of horseflesh is not at hand, when the season arrives, the only opportunity of properly working such land may be gone. It is, therefore, admitted that more horses than are absolutely necessary are frequently used in a plough during the winter, but why are not such horses yoked abreast in pairs to do the light summer's ploughing? But no; be the weather ever so fine, and the ground ever so well pulverized, in certain districts, never less than three horses, and those in a line, are seen at plough. Let no one rashly assert that all land can at all times be ploughed with two horses. Some of the clays of this county would convince the most sceptical, and the trampling of the land horse in wet weather is always injurious. Yet the constant kneading of the waxy subsoil, from four or five great horses always walking in the furrow, must tend to make it impervious to water, and this is hardly ever counteracted by the use of the subsoil-plough. Cart-horses are seldom baited in the middle of the day, but work from 7 till 2 or 3 o'clock. The winter provender is chiefly oats, beans, hay, and corn-chaff, and the stable management is generally pretty

good. On some of the sandy soils and in the south of the county pair-horse ploughs are common; hardly any oxen are used for labour. Buckinghamshire has often the credit of producing those magnificent dray-horses for which the London breweries are so celebrated. These noble animals are not bred in Bucks, but are purchased from Warwickshire and the northern counties, especially at Rugby Martinmas fair. Two-year old colts are grazed on the rich pastures for about twelve months, by which time they become well furnished and very fat. Dealers then buy them for London and elsewhere, and some idea of the extent of the numbers which are purchased may be formed from the fact that one Kentish dealer, during five months of the last year, paid for colts, in the neighbourhood of Aylesbury alone, the large sum of 9000*l.* The prices which are realized for these horses are sometimes very great: 50*l.* is a common figure, while prices varying from 60*l.* to 80*l.* are sometimes heard of. Some farmers graze eight or ten of these colts, and they pay from 10*l.* to 12*l.* for a year's keep; but they are exposed to more risk than cattle, as in cases of death, accident, or blemish, the losses with horses are very severe. Most of the dairymen breed a foal or two; these are sold off as sucklers, or kept till they are two or three years old.

Manures.

There is nothing very commendable in the manufacture of farm-yard manure. On arable lands, where there is plenty of straw, there is little animal excrement to enrich it; and on grass farms there is often an insufficiency of straw to keep the cattle clean. On the former, it often happens that a dry cow or two, a few young stock, with some store pigs, constitute the whole force for eating and treading into manure 100 acres of straw. In making manure the two agricultural districts sometimes assist each other. The grass-land farmer sends his store cattle or dry cows to his neighbour's yard, where they have an abundant supply of straw gratis, the owner of the stock supplying each with a linseed cake daily; then in the summer the arable farmer sends his colts and other stock into the grass-grounds, where he pays for their keep according to the size of the animal and quality of the grass. North of the chalks, the farm-yard manure is mostly applied for turnips and beans: on the Chilterns it is more often used for wheat. The former appears the most reasonable way of dressing the land, especially as wheats, when heavily manured, are often attacked by blight and mildew. Manure for grass-land is by some applied directly the hay is off; by others it is carted on during the winter months. The liquid manure is too often allowed to run away, and, in more instances than one, on grass-

farms, where stalled cattle were consuming large quantities of oil-cake, this expensively-made manure was thrown into loose heaps, and the rich liquid escaped into the next ditch. However, the drainage of a steading is sometimes used in partially irrigating a grass-field, or is more frequently collected in a tank or bog-hole. It is pumped up from thence, and applied to the meadows from a cart, and is found most efficacious in the months of April and May. An enterprising lady, who is a considerable landed proprietor in the vicinity of Aylesbury, tried the effects of charcoal on the sewage manure of that town. Tanks filled with that deodorizer were built, but either the best of the manure escaped through the charcoal or the scheme was not properly supported, for the tanks are now removed, and the filth of the town once more poisons the atmosphere and blackens the little stream into which it flows. Aylesbury being built on a hill is particularly well situated for applying its drainage in irrigation.

Chalk is the only mineral manure extensively used in Bucks. On the Chilterns it is generally within an easy distance of the surface. It is most commonly applied to the land from pits or wells sunk in the fields. These pits are about 20 feet deep, and the chalk is drawn up in baskets by a wheel. From 90 to 120 loads, of 16 bushels each, is the usual dressing. The cost is now 5*d.* per load, digging, drawing, and barrowing out; 3*s.* per 100 loads, spreading; and 4*s.* per 100 loads, levelling in the pits. The effect of this chalking will last well 50 years. Take the following for example: in a crop of winter oats at Hambledon last harvest a marked difference was observed; and, on threshing, one portion of the field produced a *quarter* per acre more than the other, and the difference was wholly caused by the most productive portion having been chalked 39 years ago. Such lasting and satisfactory results are most encouraging, but the great expense of this outlay could not be expected from an occupier without lease or tenant-right. Perhaps it is due to the absence of this security that so little chalking is done. In the localities where chalk is carted from adjacent pits, or fetched from a distance, a smaller dressing is considered sufficient, and probably a milder dose might be as well on the land above mentioned; but, where shafts have to be sunk and the chalk barrowed, a small coat is in proportion more expensive than a larger one. Lime is not much sought after for manure: it certainly does not possess the mechanical powers of a heavy dressing of chalk, by which land is more easily ploughed with two horses than it was previously by three; but where soils are deficient in calcareous matter, and chalk is distant, lime, from its lightness and powerful effects, is the best manure that can be used. Some lime applied to a field of undrained clay-land was reported to have

done harm rather than good, which might naturally have been expected.

Of *artificial manures*, the most common are guano, dry bones, and superphosphates. No great amount of any of these is used in the county. Superphosphate succeeds well for roots on the chalks and oolites, and on any land with a dry subsoil. At Burcott Lodge some very interesting experiments in the growing of turnips with sundry manures were made last year. Sixty yards of farm-yard dung per acre were tested against 3*l*.-worth of various artificial manures, and dissolved bones and guano produced the greatest weight. A portion of the land, left without any dressing, grew but *one-fourth* of the weight of swedes. This very spirited agriculturist has this autumn applied dissolved bones, at the cost of 60*s*. an acre, to his wheat crop. The result of this experiment will be eagerly watched, for at present it is considered that no artificial dressing for cereals is so cheap or efficacious as guano.* Rags are still used in some parts of the county as a manure for wheat and other corn crops. Those from paper mills are considered best, as they are chiefly woollen. Such rags cost 50*s*. per ton, and 5*s*. extra for cutting and sowing. From 6 to 10 cwt. per acre is a fair dressing. Rags are objected to by some, as tending to produce mildew. Ashes are on the decline; some, as well as soot, are still applied to the seeds; but ashes are more generally used for turnips, being either drilled alone or in conjunction with artificial manures.

IMPLEMENTS.

In almost all parts of the county iron ploughs are rapidly superseding the old wooden ones. Indeed, improved implements seem gradually extending; for, as the old-fashioned things are used up, more efficient substitutes are introduced. The waggons are light and well made, but the same compliment cannot be passed on the carts. In several instances there are light one-horse carts, and the great common carts of the county with shifting ladders are used for several kinds of work. The most astounding revolution has lately taken place in threshing-machines. A short time since, only a few horse-machines were in the county; now there are several portable steam-engines, which do their work most admirably. These steamers are let out at 25*s*. or 30*s*. a-day, and are constantly employed. This improved method of threshing is very opportune, for hand-threshing wheat had become almost impossible, and labourers do

* The writer is informed by Mr. Vallentine, the agriculturist referred to, that "the bones produced eight bushels per acre over the unmanured part." He adds, that on his farm of 260 acres he has spent 400*l*. in two years for artificial manures with decided success.—Nov. 1855.

not now covet using the flail on spring corn. It is not likely, from the size and situation of the farms, that fixed steamers will become general. In a tour through the county, only those at Fawley and Riding Court were observed.

IMPROVEMENTS.

The greatest improvements which have taken place since the times of the last Report have been brought about by inclosures. Open fields and common lands are an effectual barrier to all progression, and it is extraordinary that, when the advantages are so manifest, lands should so long remain uninclosed. The evils of common fields and the benefits of inclosing have been so fully detailed in the Oxfordshire Report, that it is quite unnecessary to repeat them here. But let any one who wishes to see the horrors of open lands visit Great Marlow Field. There a long contemplated inclosure is now being carried into effect, and on that fine expanse of gravelly loam, one-fourth of which should be under turnips, not a root is to be seen. The field is commonable night and day to the whole parish, from the end of harvest, here always early, to the 28th of October, so that if any unfortunate farmer grew a crop of turnips he would probably have some other person's stock eat them. Such absurdities will soon be extinguished; but there are some evils originating with open fields which are not ended at the inclosure. Where open fields existed there were no detached steadings, but the church, houses, farmbuildings, and cottages were all clustered in one spot. And unhappily there they are still, most of the lands of every occupation lying anywhere but where they should, for it is impossible for each farm to have its land near the village. The disadvantage of this, and the loss of labour in horses and men, can be well understood. Inclosures are now better managed than formerly; and instead of costing half what the land was worth in law expenses and making worse than useless fences, a parish can be inclosed under the present Act, and the roads made, at a cost of 30*s.* per acre, which is generally defrayed by the sale of waste land. There are but few tracts of open land now, and those are mostly commons left open at the old inclosures. Several of these are now coming under the notice of the Commissioners: among others, Wycombe Heath is just allotted, and the improvement of the country is already manifest. The following inclosures have been effected and the awards enrolled since Mr. Priest wrote the last Report in 1809:—Newport Pagnell, Bledlow, Marsworth, Barton-Hartshorn, Ivinghoe, Farnham Royal, Whaddon and Nash, Datchet, Haddenham, Mentmore and Ledburn, Newton Longville, Artwood, Monk's Risborough, Whaddon Chase, Brickland, Quainton, Oakley, the

Kimbles, Ellesborough, Long Crendon, Great Horwood, Shenley Common, Latchmere Field in Chalfont St. Peter, Marsh Gibbon, and Little Missenden. The undermentioned parishes have tracts of land amounting to nearly 6000 acres which are now under the powers of the Inclosure Commissioners:—Great Missenden, Penn, Hitchenden, Great Marlow, Cheddington, Pitstone, Shenley, Hughenden, Halton, and Wendover.

The principal wastes are to be found on the Chiltern Hills, especially on the southern side, where most of them are so barren that they would not pay for cultivation, though the great majority might answer in plantation. Beech trees appear indigenous to the chalks, for they cover the hills to the south of the county. The beech-wood is of little value for agricultural purposes, and is principally used for making chairs. A most extensive manufacture is carried on at and around Wycombe; and at Chesham quantities of bowls, shovels, hoops, &c., are made from this wood. There are not many large woods about other parts of the county. Whaddon Chase was happily inclosed 10 or 12 years ago: it produced some good oak and underwood, but the latter was much injured by the stock which the commoners from several adjoining parishes turned into the Chase. A great portion is now grubbed. The soil is clay with a large admixture of sand in some parts, and the greatest benefit has accrued to the proprietors and the farming of the neighbourhood from the inclosure.

Buckinghamshire suffers but little from hedgerow timber and small inclosures. To the north of Buckingham too many worthless ash cumber some of the arable fields; but from one end of the county to the other there exists the barbarous custom of lopping off all the branches from the hedge-row timber, and leaving only a bunch of leaves at the extreme top, the tree thus presenting the appearance of a household mop. The bad taste and stupidity of this plan are obvious. The sprigs which are cut off will hardly pay the cost of lopping; the timber is so knotted and injured that it is fit for nothing but the fire: and instead of a tree being a beautifying object, it has a most wretched and poverty-stricken look. A few proprietors have rushed into the opposite extreme, and will not allow a twig to be touched. Branches sprout out at a few feet from the ground to the great injury of the land and destruction of the fences. Left in this natural state, the trunk furnishes but little timber, and the tree looks nothing better than an overgrown bush. No doubt almost all hedgerow timber around ploughed land is best grubbed up; but if a few trees are cultivated for profit or ornament, trimming them up to a reasonable height enhances at once their beauty and their value.

Very little underdraining is required in the south of the county, with the exception of the land-springs and heavy loams of the plastic clay. Some of the calcareous clay beds, at the foot of the chalk hills, are drained with malm or rag, and on parts of the oolite and greensand stones are employed in draining. If these materials are not on the spot, pipes are cheaper, and they are now generally used in draining arable land. Peculiarly stiff clays have only been effectually dried by drains up the furrows and others at right angles passing quite across the ridges. On some adhesive soils attempts have formerly been made to drain them with bushes or stones, but, as these are now worn out, in redraining the land it is common to run the fresh drains obliquely across the old ones. Of course there are numerous ways of underdraining, varying with the means, the ability, and caprice of the drainer: but the most general mode is to pipe-drain strong arable soils 3 or 4 feet deep up the furrows, notwithstanding the slight curves and irregular width of the ridges. The labour of this when the clay digs freely is from 20*d.* to 2*s.* a chain of 22 yards. One great reason for the only partial success of draining strong lands in this county is, that it is hardly ever followed by subsoiling or even deep ploughing. On pastures it is more common to drain with turf. This is seldom done deeper than 30 inches, and on a stiff clay will sometimes last 14 years, and cost 10*d.* per chain. The deep and regular drainage of grass lands is not common. The grounds, which are naturally clayey and cannot bear treading in the winter, should be kept free from heavy stock; but unless they produce rushes or coarse herbage, few would drain them. And in removing the under water from lighter pastures outlets are provided for the excess of water, but there appears no desire to remove every drop of moisture from the subsoil. With the exception of Claydon, but little of the Government draining money has been expended in Bucks.

Farm Buildings.

The bad situation of most farm-steadings has been already mentioned, but in addition to this evil the agricultural buildings throughout the county are in themselves bad. They are badly arranged, insufficient, and built of inferior materials. Barns, of which there are more than enough, in conjunction with other buildings, generally form the outside of an irregular space called the yard, and perhaps the only shed that opens into this yard is the waggon-hovel! Stone is plentiful in some districts, but farm buildings in the south are boarded and thatched, and even in the Vale of Aylesbury, where hardly any straw is grown—certainly not so much as is wanted for the cattle—there buildings are also

thatched. In these defects the county of Bucks is not peculiar, and a more pleasing task will be to mention a few of the improved farm-buildings which have lately sprung up in various parts of the county.

Close by Eton, at Riding Court, a very complete steading has recently been erected in a substantial and efficient manner. It has a fixed steamer for threshing, cutting chaff, &c., a range of barns towards the north, convenient yards, and cattle stalls—in fact all the conveniences of a complete homestead. At Woodlands, a little south of Beaconsfield, an excellent set of farm-buildings is now being reared for the new tenant; and at Latimer, Shardeloes, Claydon, and other gentlemen's seats there are very good buildings, but these are in the occupation of the proprietors. At Fawley Court, the feeding-house which has been already spoken of, as well as the sheep-shed, engine-house, and other premises, has been erected by the enterprising and wealthy gentleman who now holds the lease. It would have been better (and money seemed no object) had all the old buildings been removed, for, as it is, the clever machinery is huddled together in the original barn in such a manner that, when all is going, the place seems alive, and yet no more result is obtained than is commonly produced by more sober and less complicated performances. For instance, the turnips are deposited under a little open shed, and a boy places them one by one in an elevator which carries them over the threshing-machine to the highest point of the barn roof. From thence they descend, pass through the washer, are first sliced, then ground, and afterwards by another elevator taken up and emptied into a hopper. They are discharged at intervals from this, mixed with cake and chaff, let down into a bin below, and shovelled into trucks, which are pushed on a tramway into the feeding-house, and served to the cattle. Now all this is admirably done, but the space these turnips travel is really wonderful, and with the old buildings it was not possible to arrange it better. It is very pleasing to notice the improvements which have been recently made in the management of the stock on this farm. Two or three years ago, a lot of inferior steers, some of them clipped, were standing with outspread hoofs on slippery splined boards, and pigs had to go up stairs to a similar bed, none the more fragrant or healthy for being situated directly over the manure pits. Now, beautiful Hereford oxen repose in comfort in well littered stalls, and sleek-looking pigs seem to enjoy the luxury and warmth of a bed of clean straw. The greatest improvement in farm-buildings in the county is to be seen on the Wing and Aston Abbotts estate, where not *one* steading but *several* have been lately entirely built by the noble proprietor. Most of the farmhouses, as well as the

buildings are new, and the convenient arrangement, the solidity and perfect execution with which they are built, reflect the highest credit on the noble Lord's energetic surveyor. In these buildings the house, offices, &c., occupy the south of the square, a small barn the centre of the north, while stables, cow-houses, cattle-sheds, piggeries, &c., occupy the rest and the two sides. The enclosure is generally divided into three well proportioned and warm yards. The materials used are bricks, slates, oak, and the best foreign deal. The house and premises just completed at Aston were removed from the middle of the village to a convenient spot on the farm, and cost in erection 1572*l.* Where so much is really good it seems captious to criticise, but if there is a fault in the arrangement of these buildings, it is that the barns are too small. Supposing all the corn to be threshed out of doors, the farmer requires space for two or three sorts of unwinnowed corn. There are many other respectable farm-buildings in the county, for instance, those around Cheneys; and in the north, the premises of Snelson, reared almost exclusively by the present enterprising tenant; but those described are considered most worthy of notice.

From the numerous varieties of soils it will be readily imagined that the rents of the county vary much. In order to arrive at some general idea the county was divided into six different districts, in each of which the rental of four varying farms was taken, and the average of the four was supposed to be a fair criterion of the rent of the district. They are as follows:—

Land south of the Chilterns	35*s.*
The Chiltern Range	20*s.*
The mixed loams of Central Bucks	30*s.*
The Vale of Aylesbury	42*s.*
The dairy lands of the Oxford clays	22*s.*
The oolitic soils of the north	28*s.*

This gives an average for the county of about 30*s.*, which is not 2*s.* 6*d.* more than it was in 1809. The rental in the different districts of course varies greatly; for instance some lands of the Chilterns are let as low as 10*s.*, while for the very best 30*s.* is given. In the Vale 30*s.* and 35*s.* is the common price of dairy farms, and the grazing lands let from 45*s.* to 50*s.* an acre, and even some at 3*l.*, but this latter figure is generally only paid for accommodation land, and is hardly ever given for purely agricultural purposes.

Mr. Priest, in his last Report, mentions a circumstance highly creditable to the clergy of his day. There was only one parish, Great Marlow, in the whole county, in which tithes were taken in kind. Now a great many parishes are tithe-free, for at the inclosure allotments of land were given in lieu of tithes. In some parishes where no land was set out, an annual payment or

corn-rent was adopted, and the Tithe Commutation Act did not affect half the parishes in Buckinghamshire. These corn-rents or rent-charges are now mostly paid by the landlord. The vicarial tithes run from 1*s.* 6*d.* to 3*s.* 6*d.* per acre, while the large tithes are much heavier, generally one-sixth or one-fourth of the rent.

In 1809 the amount of poor's-rates was fearful. In one parish they had been as high as 21*s.* in the pound, and several instances were given where they ranged from 8*s.* to 14*s.*; and even in the later days of the old law, the poor's-rates in Haddenham were so enormous, that some of the land for a long time was tenantless. The average of the poor's-rate throughout the county was, in 1809, 5*s.* 2*d.*; it is now happily reduced to 2*s.* 4½*d.* in the pound. Still, as compared with some other counties, the state of pauperism is by no means satisfactory. In the commencement of the present year, in the nine unions into which Bucks is divided, 11,112 persons were receiving parochial relief, which, taking the population of those unions at 143,509, shows that every 13th person is a pauper. In Durham and Salop there was only one person in every 21 of the population in receipt of parochial relief. By the last Poor Law Board returns, the poor's-rate for Bucks amounted to 83,698*l.* 2*s.*, and the receipts from other sources were 2828*l.* 3*s.*, making a total of 86,526*l.* 5*s.* The in-maintenance of the poor cost 6998*l.* 3*s.*, and the sum expended in out-relief was 44,924*l.* 8*s.*, so that the actual maintenance of the poor does not absorb 5-8ths of the sum collected. Of the remainder, 214*l.* 16*s.* was spent in law, and 1566*l.* 10*s.* was swallowed up by constables and proceedings before justices. The county-rate for the last year amounted to 14,220*l.* 3*s.* 9*d.*; the assessment of the county being 758,410*l.* Just now the county expenditure is very heavy, for there is the new lunatic asylum, and new gaol, the latter of which cost this year, for instalment and interest, 3160*l.*, and still leaves a debt of nearly 3900*l.* Although from the high price of provisions the poor's-rates are slightly enhanced, it does not appear in this county that the amount of pauperism increases with the price of grain. In January, 1852, with wheat below 40*s.* a quarter, the total number of able-bodied paupers receiving relief was 2045, while in January, 1854, when wheat had doubled its price, the number was 1920, being a decrease of more than 6 per cent.

Buckinghamshire pays a heavier land-tax than any other county in the kingdom. It is assessed to the property-tax at 875,350*l.*, and the land-tax is 46,550*l.* 16*s.* 1½*d.*, which is nearly 1*s.* 1*d.* in the pound. There is also the large sum of 2170*l.* 19*s.* 4¾*d.* redeemed, which, if added to the amount now paid, gives the original tax at 68,252*l.* 15*s.* 6½*d.*, or more than 1*s.* 6½*d.* in every pound's-worth of property in the county.

The sizes of farms mostly vary from 100 to 400 acres. There are not more than 50 which exceed that limit, and the general average is certainly under 200 acres. The greater part of these are let from year to year, with a six months' notice to quit. There are a few leases which extend from 7 to 21 years, and in the southern extremity of the county there are agreements, which require a two years' notice to terminate them. Provided these agreements contained a compensation clause, for permanent improvements, they would be much preferable to leases. A bad farmer or disreputable tenant need not then be a twenty years' burden to an estate, while the good farmer would be repaid for his chief expenditure, and have time to look about for a fresh occupation.

Mr. Priest, in his able Report, heaped a series of well-merited strictures upon the roads of the county. In his journeys from one parish to another, he encountered some really serious adventures, and a more modern writer says, that one might as well attempt to drive into the ocean, as to venture with a respectable vehicle over the field-roads. There can be no doubt that very considerable improvements have recently been effected in road-making. In the Chiltern district, where flints are plentiful, they are as good as the most fastidious could desire. But in districts where hard materials are scarce, some of the parish roads are very bad, and the turnpikes are by no means perfect. The inclosures greatly improved the transit from one parish to another, by making good hard roads, but the farm-roads on clay soils are still in a dreadful state, and during wet weather and the chief part of the winter are deep sloughs of mud. Were roots grown on such land, it would be next to impossible to convey them to the homestead. The northern, southern, and eastern parts of the county are well furnished with means of transit in the shape of railroads, canals, or rivers, but the south-western district, especially about Thame, enjoys none of these conveniences.

There is nothing particular to commend or censure in the labourers of Buckinghamshire. They are similar to other labourers of middle England, and therefore there is room for much improvement. As labourers, they certainly have not arrived at that ideal state of perfection where, as represented in the Society's Journal, vol. xv. p. 108, four men fill ninety-six cartloads of manure in the day; and women are not yet expert in sowing artificial manures. A man in Bucks considers it a very fair day's work to fill twelve or fourteen loads of manure, and women do not generally venture into the fields but at hay and corn harvests. In addition to their domestic duties, the poor women, as well as their children, are employed in lace-making and straw-plaiting in some parts of the county. Making pillow-

lace is wretchedly paid for now, and straw-hat braiding is not so lucrative as formerly, but good hands when the trade is brisk can still earn 8*s*. per week. The straw costs from 6*l*. to 10*l*. a ton; it is sometimes purchased in the neighbourhood, but in adverse seasons, when blight prevails, it has to be procured from a considerable distance. An expert and industrious woman at lace-making can rarely earn more than 6*d*. a day. The wages of agricultural labourers in Bucks are now 11*s*. and 12*s*. a week. The ploughboys, who are hired by the year, have from 3*s*. 6*d*. to 5*s*. a week, and 20*s*. to 60*s*. at Michaelmas. Women's wages are from 8*d*. to 10*d*. per day. The prices of task-work vary with the locality and season, but the average price of mowing clovers is 3*s*., and of natural grasses 4*s*. per acre. Hand-hoeing broadcast turnips twice costs 9*s*.; when drilled and horse-hoed, from 5*s*. to 6*s*. The greater part of the corn is bagged or fagged, cut with a hook close to the ground, which costs from 9*s*. to 12*s*. per acre. Towards Aylesbury, however, the wheat is mostly reaped. This may cost a little less, but afterwards there is the haulm or stubble to cut, which is done for 2*s*. or 2*s*. 6*d*. an acre, the man using a scythe, and heaping the stubble with his leg. The arable farmers sell their stubbles to the dairymen for about 6*s*. an acre, the purchaser paying for the cutting and carting it away. On the Chilterns, and in other parts of the county, barley and other spring corns are mown. The corn-ricks, which are mostly rectangular, are very well made, but cannot be compared in neatness or beauty to those of Oxfordshire. The hay-ricks in the grass grounds are built in a conical shape, taken up gradually to a sharp point, and covered at the top with a small portion of well-placed thatch.

Among the many causes which assist in degrading the poor, insufficiency of cottage-room, with bad situations and frequently high rents, is certainly among the chief. Some wealthy proprietors seem fully alive to the necessity of providing the poor with proper dwellings. At Cheneys and Aston Abbotts some really admirable cottages have been lately built. The former is, indeed, a beautiful specimen of an English village. The noble old manor-house, the church, the school, the elegant, commodious, and well-arranged cottages, are all pleasing and useful mementos of that illustrious family whose honoured dead now sleep peacefully in that quiet church. In these cottages comfort has not been sacrificed to architectural beauty, and each, having an ample garden, is let at a very reasonable rent. At Aston Abbotts twelve new cottages are just completed. They are built in groups of four each, and are constructed in a most handsome, substantial, and convenient manner, at a cost of 160*l*. each. The noble proprietor of this estate sets a good example to all owners of the

soil by providing excellent buildings, not only for his yeomanry but also for his poorer tenants. Other very good cottages are springing up in various parts of the county; some very excellent ones are just built at Hambleden, and as the good work has been so ably commenced, it is hoped it may be extended on a fair and economical basis to those wretched localities where it is so much needed. Garden allotments are not very numerous; but where well situated, and not allowed to exceed 40 poles, are of great advantage to the poor. Those at Hambleden are well cultivated, and they are much valued and appreciated by the humble tenants, who with cheerfulness and regularity pay the rent of 3*d.* per pole, all other charges being defrayed for them. The kind-hearted gentleman of whom these allotments are rented keeps an acre in his own hands, on which, by spade husbandry, he employs the surplus labour of the village.

It is unnecessary here to enlarge upon the vices and short-comings of the labouring population, to detail their wants and hardships, or echo the excellent recommendations for their relief, which have appeared in the Reports of other counties. It is certainly a pleasing feature of society in the present day that the upper and middle classes not only express a regard for the welfare of their poorer neighbours, but also bestir themselves in active attempts to better their condition. The clergy and gentry of Bucks seem to work well together in their endeavours to elevate the condition of the labouring poor; and, while education and plain religious teaching are happily extending among them, their bodily comforts are not unheeded. Unity of action frequently does more than individual exertion, and charitable societies are productive of much good. It is of the greatest importance to instil into the poor habits of providence and forethought, and for this cause the South Bucks Friendly Society was established. By monthly payments the poor can secure relief and attendance in sickness, annuities after the age of 65, or 4*l.* payable at death. This society was first founded in 1832 for the district of Missenden only, but in 1835 was extended to nearly forty parishes in the south of Bucks. The society seems in a flourishing condition, to which prosperity the inappreciable services and long-continued and untiring self-devotion of the honorary treasurer have not a little contributed. From a valuation made of the society's liabilities and assets in 1844, the balance in hand was 428*l.*, while a later valuation increases the balance to 1140*l.*, the whole of the assets being valued at no less a sum than 18,195*l.* From the last cash account published in June, 1854, it appeared the actual amount of stock was 7181*l.*, and that the number of members was 1070. The working of the society cost 187*l.* To cover this the honorary subscriptions for the year amounted to 70*l.*, the admission fees,

fines, &c., bringing the receipts up to 92*l.*, leaving the sum of 94*l.* to be supplied from the surplus fund, 43*l.* of which is furnished by the interest of the balance. The members' fund shows a clear gain of 308*l.*, while the year's interest amounted to 254*l.*, so that after paying the above 94*l.* for the management, the increase of the stock for the year was 468*l.* Such societies as these are of incalculable benefit to the poor, and the want of method, common honesty, and solvency, which characterises most of the labourers' medical clubs, contrasts strangely with the able management and flourishing condition of the South Bucks Friendly Society.

Improvements Required.

Considerable improvements have been made in the farming of Buckinghamshire since the Report of 1809, especially during the last ten years. Still the progression is far from wonderful, and not to be compared for a moment with the rapid strides agriculture has made in other counties. The last annual meeting of the Royal Agricultural Society was held in a district whose progress has rightly been the theme of much admiration. One of the principal reasons assigned for that progression was the variety of soils in the county. But in Bucks there are chalks, clays, rocks, sands, gravels, loams, fertile pastures, cold grass-lands, flooded meadows, and barren heaths. Why not the same amount of progression, for surely the variety of soils is sufficient? There is but one real answer: in one county the tenant has security for his capital; in the other comparatively none. Wherever great progress in agriculture has been made, there security to the tenant in the shape of leases, tenant-right, compensation-clauses, or something of the kind, exists. As the rule seems almost without any exception, it is singular that almost every probable and improbable cause should be thought of and discussed before the real one is mentioned. The chief improvements in Bucks are the inclosures, the removal of useless hedges and timber, the use of corn and cake for sheep, the extended cultivation of root-crops (not above 1000 acres were grown in 1809), the operations of the New Poor Law, and latterly the almost total destruction of game. On the latter head it must be observed, that, however great the regret at seeing the first and most splendid estate of the county pass into other hands, much good has resulted to the farming interest from its division. When that ducal estate was entire, the whole country was one large preserve; since then hardly a tenant has to complain of any injury he has sustained from game. The stag-hounds are considered by the farmers in the Vale of Aylesbury a sad nuisance. The pastures during the winter are covered with ewes heavy in lamb, and in addition to the common evils of turning

cattle together and breaking down fences, heavy losses are sometimes sustained from this cause among the ewes.

From what has been said it will appear that some vast improvements are still required in Buckinghamshire. Security of tenure, proper farm-buildings for the shelter of stock and manufacture of manure, draining, field-roads, and better management of clay soils, may be considered among the most prominent. With regard to breaking up grass-land, a notion prevails that great improvements would be effected by this. Certainly land which, when ploughed, would carry stock and grow roots, and which cannot now produce a ton of hay per acre, is best ploughed up from grass. The improvement effected by the conversion of *such pastures* into arable land is very great. Let any one, who knew the Snelson farm, in Lavendon parish, in its original state, compare it with its present condition. Before the enterprising tenant occupied it (by-the-bye, he has a 21 years' lease), the farm was chiefly in pasture, some of which produced little grass and was covered with ant-hills. A lot of useless wood land was grubbed, at the rate of 8*l.* per acre, and above 100 acres of the worst grass was banked over and then dug up, at the cost of 3*d.* per pole. Beans were dibbled on the flag, the rows having been previously marked out, and that crop followed by wheat; then beans and wheat again. The land is now brought into a regular rotation; and last year the average produce of the farm was 6 quarters of wheat, 10 of oats, and 5 of beans. In addition to all this increase of corn, as *much stock is kept on the farm as formerly;* so there is the *gain* to the tenant of the *corn, less* the cost of producing it. Some farmers, in speaking of such land in 1809, were of opinion that 3-4ths might be ploughed and yet the same stock kept as if none were ploughed. On which Mr. Priest remarks, "It would require so much supposition to make this clear on paper, that few would believe it; let some spirited farmer show it by practice, and the point is carried." This has been done over and over again since then, but in no instance more satisfactorily than in the one just quoted.

But the case of this farm is not a general one. In the county, the greater portion of the inferior or unprofitable grass-land rests on a very stiff clay—land that if ploughed would produce after the first few years but little corn without a great expenditure. The farm above noticed is situated on the cornbrash, or forest marble of the north, which is more easily cultivated than the Oxford clay; but, as a general rule, the agriculture of Bucks would not be permanently improved by the cultivation of the cold pastures. Nay, on the contrary, there is much clay land now ploughed that would be better in grass. The readiness with which such lands become useful pasture, is well known; and clay

pastures produce a greater quantity of milk and of better quality than gravelly or sandy soils. Doubtless, where there is no ploughed ground on a grass farm, be the land ever so stiff, a few acres of pasture might be advantageously broken up for arable cultivation. In addition to the straw and provender it would produce, it would furnish employment for the few horses which must be kept, and a little clay land can generally be managed better than a large tract. As a general rule, cheaper and equally efficacious improvements are to be effected on such lands by their remaining in pasture; and before the cold clay grass-lands are extensively broken up, there should be a more satisfactory management and profitable return from the stiff arable soils of the county, for such lands which require most expense too often return the least profit. Now, the expense of these arable clay farms is of no ordinary kind: think, for a moment, of the cost of tillage, the heavy ploughings, and the expensive and oft-repeated fallowings these lands receive. Again, present crops and present prices are no criterion: it is not unlikely that when the piping times of peace return, the prices which ranged from 1848 to 1853 will return also. Fleets of noble merchantmen, laden with corn from the Baltic and Black Seas, will again cover the bosom of old Father Thames; but it is not likely that those splendid ships will bring, from the countries washed by those seas, any fresh butter or milk for the Londoners' breakfast. Therefore it may be naturally expected that the price of dairy produce will, in the average of years, be more remunerative than the price of grain.

From the description given of the management of the poor grass-land, it will be gleaned that it is by no means satisfactory. There are those stiff wet clays without proper ditches, water-furrows, or under-drains to carry off the surplus water. Some fields are constantly mown, and supplied now and then with a slight dressing of manure: the others are always fed, but the droppings of the cattle are never spread about; and though they can produce nothing after November, the grass-land is poached by the cows all winter long. No course of management can be much worse than this, and nothing but a considerable expenditure and different treatment will make those poor dairy farms more profitable. They certainly are not highly rented, and yet there is no improvement or prosperity. The observations made in the last Report are equally true after the lapse of nearly fifty years. Mr. Priest says, "Upon some dairy farms the farmers barely exist;" while a modern writer remarks on this district, "it affords little rent and a scanty existence to the husbandman." It is natural that the same causes should produce the same results, and as some of the dairy lands of Bucks are managed as they were in the beginning of this century, the poverty which existed then

exists now, perhaps in an aggravated degree. There are a few of the grass-lands managed very fairly: about Marsh Gibbon and the Claydons are some dairy grounds which appear to be well farmed, and on them the tenants seem to thrive. But these do not constitute the majority of instances; and the few remarks which follow apply to the barren and neglected grass-lands which so extensively prevail in Bucks.

Now the cause of this barrenness is, that the ground is a tenacious, compact, and adhesive mass of clay. It combines with and obstinately retains moisture, thus effectually excluding the action of the atmosphere. The ground is a puddle in winter, and cracked and dried as hard as a brick in summer. The soil and subsoil should be in such a state of friability that roots could easily penetrate them, and they should retain moisture by capillary attraction in dry seasons, and in wet give off the surplus by filtration. The most important elements of vegetation—air, water, heat, and light—would then have access to the soil, and manure would supply decomposing organic matter for them to work on. But now, when the sun's rays attempt to warm the surface, the ground being damp and having little animal or vegetable matter in it, cannot retain the heat. Clay soils, to be fertile, should contain 10 or 12 per cent. of organic matter; but some soil taken from a poor-clay meadow near Bletchley Station, on being analysed, gave but little more than 3 per cent. By under-draining, clays soon become friable enough for the grass-roots to strike deeply and freely into the subsoil; this would assist the passage of the superfluous water, while the natural tenacity of the soil would be more likely than sands or gravels to retain sufficient moisture. In order to bring about these good results, first let proper ditches be made, sufficiently wide and deep to carry off all the surplus water. These ditches should be well trimmed and cleansed every year. Next let under-drains, 3 feet deep, be placed up every other furrow, and, in addition to this, in low spots where the water is apt to stand, surface-drains or water-furrows should be cut. The parallel under-drains had better empty into a main drain about 20 feet from the ditch, and have but one mouth for a moderate-sized field. There would then be but few outlets to clear, and, if the mouth was properly made, would prevent injury from the treading of cattle and stop the entrance of vermin. The land should be grazed as much as possible, but never stocked during the winter months. Cattle then derive no benefit from wandering cold and wet over the land, and they so puddle the soil that the drains cannot properly work. Organic matter should be supplied in the shape of manure, while the drainage of the yards, and composts formed of roadscrapings, sand, and decayed vegetable rubbish, would be very beneficial. A

dose of 2 or 3 cwt. of guano per acre, in the early spring, is the best artificial dressing for poor grass-lands; if deficient in phosphates, bones would do good. Most probably the pastures would be covered with hassock-grass and ant-hills. Some farmers cut these banks open, throw the soil and ants about, and replace the turf. It is a better way to mat up the hassocks and ant-hills, and cart the tufts away to a heap, and there pack them over with hot lime. When well rotted, this should be applied to the land, and some grass-seeds and Dutch clover sown, and the ground well harrowed and brushed. It is essential to try and improve the herbage by sowing a mixture of good seeds, as the sub-aquatic grasses are sure to die out when land has been properly drained. From this and similar treatment the poor pastures of the county could not fail to derive great benefit.

The improvement of arable clay-land is more expensive, but also more satisfactory, and gives a quicker return. The surface and stagnant water must first be removed by draining, before the land can be effectually cleaned or the manure do much good. This stagnant water not only makes the soil close and compact, and keeps out the air and heat which produce fermentation, but it even impregnates the subsoil with pernicious qualities which can only be removed by draining and deep-ploughing. Such arable land should be drained up every furrow, at a depth not less than 3 feet, and the ridges may be gradually reduced from their present enormous height. This must be done *only by degrees*, and the crown of the ridge enriched by constant dressings of manure. When this levelling is accomplished the drains will be at least 4 feet from the surface, but the land is not like turnip and barley soils, and ridges and furrows cannot be dispensed with, or the land ploughed, trodden on, or carted on in the wet. Some successful instances are seen in the county where these large round lands have been levelled and entirely altered into 3 or 4 yard ridges. Draining is best performed in the autumn or winter; and in the following summer, when the soil is well dried, the land should be subsoiled across the drains. This should be repeated the next time the land is in fallow, and once every eight years after that. It is the want of this deep cultivation which renders underdraining so incomplete. Long unfermented manure is best for clay soils: it assists in keeping the land loose and porous. There need be no apprehension on such drained soils lest the best of the manure should be washed away, for all clays have a strong affinity for, and the power of retaining, the effluvia arising from fermentation. It is by the access of water and air that manure is made fluid and aëriform, in which state alone it can benefit plants: but in stagnant water manure will become antiseptic and preserved from putrefying. On non-cal-

careous clays dressings of chalk or lime should be applied. Lime appears to make some undrained lands colder; but when the water is removed lime is of great service, purifying the subsoil and hastening the decomposition of organic matter. Burning clay does much good, if properly performed, but is seldom practised in Bucks. It transmutes inert matter that would have lain dormant for years, and imparts to it an enriching quality. The ashes should be black from slow combustion, not red from a strong fire. In addition to the chemical efficacy of burnt clay, the ashes act like coarse sand, and improve the texture of the soil. When drained and subsoiled, there can be no reason why clay-lands should require a fallow every three years. Indeed, when the proper period of fallow returns in the fourth year, it need not be naked and unprofitable, but crops of vetches and rape, to be hurdled off by sheep, would furnish a supply of food, as well as the very best coat of manure for such land. Stiff retentive clays might be cultivated upon the four-course rotation, thus:—1st year, rape, vetches, or mustard, fed off in the summer; 2nd, oats; 3rd, half clover, half beans; and 4th, wheat. There can be no necessity for detailing the proper cultivation of these several crops, as they were fully discussed in the last number of the Journal. A few mangolds, and especially cabbages, for winter keep, might advantageously be grown on clay soils. The latter flourish anywhere, and those last year on the stiff loams of Lillingstone and on the gravels of Beaconsfield were capital crops. It should be the object of the heavy-land farmer to provide a supply of winter provender, and keep in mind the good old saying, "No food, no stock; no stock, no dung; no dung, no corn."

Haddenham Manor Farm.

It is more satisfactory to record successful achievements than to suggest improvements, so instead of recommending any better cultivation of the lighter loams of the county, the subjoined account of the management of the Haddenham Manor Farm is given as an example of what may be done by good farming. No land in Buckinghamshire was ever more rapidly improved, and the enterprising agriculturist describes the course he so successfully pursued in the following interesting remarks:—

"The summer of last year (1853) the whole of the farm was very foul with couch and other weeds, much impoverished, and out of condition. The first process was thoroughly to clean and manure the land, and to drain it where required. The next was to get it into something like a rotation of crops as near as possible on the four-course system.

"1st. The swede crop.—The land having been well cleaned in the spring,

was drawn out into deep trenches 26 inches apart from each other, which were filled with 15 loads of pig manure per acre, then covered in as lightly as possible, rolled and drilled with 2 pounds of swede seed and 40 bushels of peat ashes per acre, and upon some portion 3 cwt. of superphosphate per acre, over and above the manure and peat ashes. The land was then rolled with a very heavy roller. When the swedes were in rough leaf they were hoed out at intervals of 12 inches apart in the rows, and the land between the rows was well and repeatedly stirred with Smith's horse-hoe during the whole of the summer, until the swedes were too large to admit of this operation. The swedes are an excellent crop for the season, and are now being sliced with the turnip-cutter for the sheep and cattle, which, with artificial food, are thriving fast.

"2nd. The barley crop,—after the swedes were fed off last winter by the sheep, having corn, oil-cake ($\frac{1}{2}$ pint of beans and $\frac{1}{2}$ lb. of cake daily), and clover-hay,—was partly dibbled and partly drilled upon the land, being once ploughed and scarified, at the rate of about $2\frac{1}{2}$ bushels per acre, in rows of 8 inches apart; the land was then well harrowed and crushed with Crosskill's roller. When the barley was sufficiently high, it was alternately horse-hoed and clod-crushed several times: the horse-hoe raising the mould so as to enable it to absorb the moisture and the nitrogen from the air, and by this means increasing the bulk; the clod-crusher pressing and consolidating the land, so as to enable it to retain what it had absorbed, and by this means stiffening and glazing the straw so as to prevent it from falling. This process was adopted on all the barley which was planted in February and March; and where it was adopted the barley did not fall, although it was a very full crop. Where this system was not entirely carried out, as was the case with the barley planted in April, the barley did fall. The last hoeing was done by men in order to hoe instead of to harrow in the clover seed which was sown upon one-half of the barley land, the remaining half being left for winter beans or pulse (beans and peas).

"3rd. The clover crop,—being French red-clover seed, was hoed in at the rate of 18 lbs. per acre on the barley land, 20 bushels of soot and 20 bushels of ashes being sown upon every acre in the month of March. The first crop was mown for hay in June, the second crop partly mown and partly fed off by sheep. Where the second crop was mown the sheep were folded, and woollen rags were applied at the rate of 6 cwt. per acre.

"4th. The wheat crop was planted on the clover ley, once ploughed, the weeds and couch having been forked out by men and boys; the Uxbridge white wheat, the Spalding and Cone wheats, were then planted in three separate portions in drills 10 inches apart; the land was then trodden by the sheep and clod-crushed several times in the autumn to consolidate it for the winter. 15 bushels of soot and 3 cwt. of salt per acre were sown upon it in the spring, the soot being intended to increase the bulk of straw, and the salt to stiffen, glaze, and prevent it from falling, as well as to increase the weight of the grain. The 10-inch rows fully allowed of Smith's horse-hoe being used in such a manner as to raise plenty of mould, and then the clod-crusher so consolidated the land and strengthened the roots of the wheat, that the straw very much resembled a reed in respect of its stiffness; this process of alternate horse-hoeing and clod-crushing was repeated several times during the spring, until the crop became the largest, and at the same time the most upright, which was perhaps ever seen when the land had been previously in so bad a state.

"The pigs during the last winter were fattened upon swedes, barley, and pulse, steamed by Stanley's apparatus. The cattle in the yards were some of them fed upon swedes, hay, and oil-cake, some upon hay, and some of the very lean ones upon straw and cut swedes. The horses work in pairs, and in Scotch carts, one horse in a cart; they are light in the leg, and yet full of bone and

muscle, and are generally strong carriage horses, purchased with a blemish, which does not affect their work, and yet prevents the price from being very extravagant."

The Haddenham Manor farm is a nice sandy loam, resting on the Portland oolite, and, as frequently occurs in this formation, has a small portion of it peat. This formerly grew hardly anything, but now oats, Italian ryegrass, carrots, mangolds, &c., flourish on it. Last year it produced a particularly fine crop of barley, the land being previously ploughed very deeply, which brought up fragments of a marly subsoil. A good dressing of lime was then applied, the barley dibbled, and repeatedly hoed and clod-crushed. The straw was stiff and bright, and the produce of the crop was 8 quarters to the acre. It is not intended to offer these or any other remarks as a model by which to farm all the light lands of Bucks, but portions of this system might be useful for almost all farms, and every intelligent man would know what part was applicable to his own occupation. The repeated clod-crushings might too much consolidate the lands of the Chilterns, and beans do not appear to flourish in that district; but otherwise the rotation of cropping, and the general high farming, especially the better manufacture of farmyard manure, would greatly improve the present cultivation of the chalks.

Many similar interesting details from various agriculturists, as well as some pleasing descriptions of successful farming, especially that on the Scotch system pursued so admirably at Winslow, could be added, but, notwithstanding the desire to confine these remarks within reasonable limits, it is feared the length has already extended itself so as to tire the patience of most readers. The writer, in drawing this Report to a conclusion, cannot dismiss it without offering his best thanks to all those gentlemen who have so courteously furnished him with such useful information, and permitted him the opportunity of inspecting their several farms. In no one instance has he to pass the questionable compliment recorded in the last Report, that certain yeomen " were very respectable men, but not over-communicative on agricultural matters." The intelligent farmers of the county appear quite willing to impart their information to others, and the writer wishes to express his deep sense of the gratitude he owes to those gentlemen, and he hopes that the strictures and animadversions he has felt it his duty to make may not offend, but provoke the energy and resolution to amend those defects which still exist in the farming of Buckinghamshire.

XVI.—*On the Chemical Changes in the Fermentation of Dung.* By the Rev. W. R. Bowditch, St. Andrew's, Wakefield.

Prize Essay.

An inquiry into the changes undergone by substances in any given condition presupposes an acquaintance with them in their normal state. The want of this knowledge in the case of manure meets every one who attempts to describe its changes in the heap, in the soil, or in the plant; and all that can be done is to use the knowledge we possess, and to confess ignorance of what lies beyond our means of investigation.

Analysts tell us for instance, that certain plants contain a considerable amount of phosphorus, and show in figures the percentage of phosphoric acid in the ashes, indicating the bases with which it is supposed to be united in the vegetable: and thus people speak of phosphate of lime, magnesia, or ammonia entering into the composition of such and such plants. But who will venture to assert that the phosphorus is contained in the living plant in the same form and combination as in the ash, or even, at present, to propose a theory concerning it as more than conjecture? * Again, sulphuric acid may be found duly tabulated with every appearance of accurate knowledge, but who will presume to limit the sulphur in plants to this particular form of combination with oxygen?

Unfortunately we are not only ignorant of the *combination* of elements in the living plant, but have yet to devise satisfactory methods by which to determine *how much of a given element* in each case really exists!

For example; Messrs. Way and Ogston have published a series of determinations of the sulphur contained by some of our cultivated crops which bears the impress of labour and competency. We might therefore reasonably expect the results to be reliable. But Mr. Sorby has another series relating to the same element which differs so widely that *both* cannot be right; nor can the differences be mere errors of analysis. Prof. Johnston again differs from both the series, and in the article of cabbage multiplies Mr. Sorby's figures by four (nearly)! and expresses his opinion upon the whole matter thus; "I do not quote more of these results, as I believe further experiments will show *the numbers obtained by these experimenters to be all below the truth.*"†

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* "One source of difficulty in these analyses (i. e. of albumen) is the presence of inorganic matter, such as phosphates, which does not, perhaps, *exist in the albumen in the same form as that in which it is found in the ashes.*"—Turner's 'Chemistry,' by Liebig and Gregory, vol. ii. p. 1266.

† 'Experimental Agriculture,' p. 103.

When such differences are found upon what seems so simple a subject among persons to whom confessedly agriculture is much indebted, we ought at once to recognize a token of our really limited knowledge and to wait patiently the period which will enable us to employ such methods of investigation as will lead to satisfactory results. Instances need not be multiplied to show that whatever conclusions we may adopt must be held subject to revision, and as merely the best guides to practice warranted by existing data.

Manure is composed of various animal and vegetable substances which have served their purpose in the economy of nature and are now to return to corruption, that they may form parts of new vegetables, and minister subsequently to the wants of other animals.

The elements of which these refuse matters are composed are few though the modes of combination are many. Carbon, oxygen, hydrogen, and nitrogen may be taken to represent the organic parts of plants and animals, while their inorganic portions appear to consist of potash, soda, lime, magnesia, silica, alumina, iron, manganese, sulphur, phosphorus and chlorine. The combinations of these elements in the materials of manure have to be broken up and a new series to arise out of their destruction before living plants can appropriate any portion to their own use, and prepare it in their structures to be fitting nourishment for animal life.

The dissolution of existing combinations and the formation of the largest number of suitable new ones is, thus, the aim of the farmer in his treatment of manure; and commonly it will be found (cæteris paribus) that he who accomplishes this end most completely and with *the least loss of manurial constituents* will obtain the best crops. These changes we have now to investigate.

Animal and vegetable substances may be kept unaltered for any length of time provided they are perfectly dry and completely protected from the atmosphere, but it is nature's invariable law that every organized portion of creation shall pass through a process of dissolution when it ceases to live and is subjected to atmospheric influence at a temperature above 32° Fahr. In every known instance *the chemical forces acting in the direction of dissolution and reconstruction are stronger than those acting in the contrary direction*, and the result is a resolution of the elements of organic substances into other, and, generally, simpler combinations.

In the case to which our inquiries are now directed we are safe in asserting that the initiation of decomposition is due to a *nitrogenized substance*, and probably also that the rapidity of the

process is proportional to the amount of these nitrogenized substances and the freedom with which they are allowed to act. An ordinary manure heap is formed of materials which have already advanced a considerable way towards decomposition, and are every moment proceeding in the same direction.

The food of men and animals contains a considerable quantity of nitrogen in the form of albuminous compounds, beside carbon in the form of starch, sugar, &c., together with water and its elements; and when these have been employed to build up the portions of the body which need renewal, and to furnish the heat necessary for vitality, they pass away as useless excreta. But upon examining these excreta we find great changes wrought in the *forms of combination* of their elements, and though, no doubt, the vital force brings about what takes place, yet these changes are in the truest sense of the word *chemical.*

Let us confine ourselves to the three substances named as forming part of the food, and to the urine only of man, the horse, and the cow, to illustrate this existing and progressive decomposition in the substances of manure-heaps *at the time of their formation.* The combinations of the food are broken up by the chemical influence of the vital force, and by the time the refuse substances are excreted in a fluid form we find some most amazing changes. Water (or its elements) has come into play to yield oxygen as wanted, and the corresponding quantity of hydrogen has been compelled to seek another element for which it could exercise affinity, and with which it could form a true chemical compound. At the same time the nitrogenized portions of the food have yielded to the forces acting in the direction of decomposition, and have given up a portion of their nitrogen to seek for some element with which *it* could combine to form a true compound. Thus expelled from old combinations, and *both in the nascent state* when they can exercise a strong affinity, the hydrogen and nitrogen meet and form ammonia, a new substance *existing in its elements* in the food, but wholly unknown till decomposition liberated together the nitrogen and hydrogen of which it is composed.

The examination of the urine of men or certain animals shows the presence of a body called urea or *anomalous cyanate of ammonia.* This substance is well known to constitute the most valuable part of guano. Urea existed in its elements in the food or it could not be found in the excrements, but the whole of its complicated structure has been built in the animal laboratory whence it issued. Its carbon left the matters with which it was originally associated to unite itself with nitrogen which had also been expelled, and these two formed the gas which chemists call cyanogen. This gas united itself with some liberated oxygen

and formed a fluid called cyanic acid, which in its turn sought and found a suitable substance wherewith to combine in the free gas called ammonia; and thus results a solid—urea—which when voided from the animal possesses no apparent property in common with the food taken in the first place, nor with the other bodies into which it is resolved almost as soon as ejected. It is itself a crystalline colourless solid, but in the presence of water soon becomes resolved into the two gases carbonic acid and ammonia.

This series of changes might be carried to a great length, but enough has probably been said to show that *at the very time* that animal excreta leave the body they are in a state of change, and consequently that what takes place in a manure heap is actually initiated as soon as its most valuable constituents become subject to our observation.

The same remarks apply to the vegetable portions. Water and a temperature above the freezing point instantly originate a series of changes which would end in the entire disruption of the substance of straw or other similar matter and bring forth a new arrangement of their elements, and these conditions are obviously present the moment litter is thrown down in a farm yard or as bedding for cattle.

We must therefore regard the newly formed heap as being in a state of change when first made, and endeavour to follow out those changes which occur subsequently by the light of the knowledge we already possess.

The decay of substances placed together in a manure heap conforms to the laws which regulate *the combustion* of similar bodies. Putting out of sight for the present the inorganic constituents we have a quantity of matter consisting principally of carbon, oxygen, and hydrogen, variously grouped to form the different kinds of vegetable tissue composing the straw and that which is voided unaltered in the animal excrements. The oxygen and hydrogen in vegetable tissue are always found in the same proportion as in water, that is eight parts by weight of oxygen to one part by weight of hydrogen.

When a rotten apple is mixed with a quantity of sound ones the parts of the latter which are in contact with the former are altered in condition and begin to decay. This well known fact is the reason for constantly examining kept fruits and removing those which show any symptom of rottenness. It is further known that when once an apple is affected the entire substance soon undergoes decomposition. Thus the putrefaction of manure is begun and propagated. Substances which are themselves in a state of putrefaction (dung of animals) are brought into contact with others which are not (straw, &c.), and communicate by that

contact their own state of change, and hence the action is propagated from one particle of matter to another throughout the heap.

In every instance of this kind *one law is obeyed*, and we think that law may be made clear to the reader though he be not a chemist. It is to be borne in mind that the substances to be changed are composed chiefly of carbon, oxygen, and hydrogen, of which the last element is incomparably the most prone to decomposition (most combustible).* Wherefore as soon as a decomposing nitrogenized substance communicates to a sound one the state of change (motion) in which its own elements are placed, the elements of that other body begin to be liberated, and the freed hydrogen seizes with avidity upon any oxygen in its neighbourhood and forms water. The liberation of *one element* is the liberation of *others*, and the carbon now seeks oxygen whereto it may be allied to form carbonic acid. But till the hydrogen has become satiated with oxygen, that is, till one of hydrogen by weight has united with eight of oxygen by weight, no oxygen can unite with carbon, or in other words no (oxide of carbon) carbonic acid can be formed.

This is well illustrated by what takes place when vegetable fibre undergoes decomposition with an insufficient supply of oxygen. Straw or wood rotting under water so change that part of the hydrogen combines with the carbon and forms light carburetted hydrogen (marsh gas), whereas under ordinary circumstances with free access of air the carbon unites with oxygen and forms carbonic acid. The firedamp of coal-pits is similarly formed by a union of hydrogen with the carbon of the decaying vegetable fibre of the coal. Again when wood or coal (which consist chiefly of vegetable fibre of identical composition with that of straw) are distilled in close vessels, where the supply of oxygen is of course limited to that contained in their own substances, water is formed as long as oxygen is supplied in sufficient quantity, and the liberated carbon has no alternative but to combine with hydrogen and form illuminating gas. Similarly, when a candle (which consists like vegetable fibre of carbon, hydrogen, and oxygen) burns, the hydrogen may be seen burning first in the blue portion at the bottom of the flame, where it forms water with atmospheric oxygen, while the carbon passes upwards into the white portion unable to combine with oxygen (to become burnt) until the hydrogen has been satiated.

This strong affinity of hydrogen for oxygen leads to the formation of a large quantity of water during the fermentation of dung

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* By this is meant, that when an existing compound containing hydrogen is broken up, the hydrogen has the strongest tendency to enter into new combinations.

as every one knows by experience, and as he might perceive *must* be the case by inspecting the chemical formulæ of the substances undergoing decomposition. A large quantity of ready formed water is added in the excrements of animals, which probably never contain less than 90 per cent., and the sum of this existing and generated moisture is increased by the rainfall. Yet we see every heap, made of *horse dung alone*, burnt, and often those of an ill-managed farm-yard are in the same condition. What renders the case more noticeable, is, that the burning is the worst when the evaporation is the greatest, and no spectacle is more familiar to an observer of the fermentation of manure than a cloud of white vapour which completely conceals the workmen who are removing a heap of 'firefanged' horse dung.

But every particle of that exhaling moisture was designed by a beneficent Providence to be condensed into a liquid charged with the precious burden which it is now bearing away on the wings of the wind. Elements of corn and cattle are volatilizing with every grain of the steam, and (in towns) are becoming sources of disease and death to those whom, if differently managed, they might feed! And why? Simply because man will defeat nature. Nature designed putrefaction (combustion) *to be slow*, and to that end required all decomposing refuse to be buried, in which case its slow but useful conversion was certain. Man on the other hand places the waste substances so that the combustion may *be rapid.* He employs the light porous material straw to mix with animal excreta, and places the whole so as to ensure a free passage of oxygen among the putrefying mass. The rapid burning of sticks is ensured by their being laid carefully across each other so as to afford the readiest access to the atmospheric oxygen, and this is a close approximation to the state of dung thrown lightly into a pit. The heat generated during its combustion converts the water of the burning wood into steam which passes freely and rapidly up the chimney, and that of dung may be seen in a still dewy morning forming a column of some twenty feet in height above its source.

But suppose all the water had been retained by the heap. Suppose the oxygen had been supplied to the decaying mass as it is supplied in the soil, abundantly but yet slowly, would there have been any firefang, or would the ammonia and other valuable products have flown away almost as quickly as they were generated? We are always wrong when we can perceive a law of nature and do not conform to it.

It has been already observed that the fermentation of the mass of materials which constitute a manure heap is begun by the putrefaction of some of the nitrogenized compounds which abound in it, and which act upon those in contact with them as yest

acts upon a solution of pure sugar. The bodies in question absorb oxygen when they are subjected to the influence of the ferment and they then enter upon a state of change. Each fermenting portion becomes itself a cause of fermentation to other portions which are in contact with it—as the rotten apple destroys the sound ones which touch it—and thus the action continues till the whole is fermented.

Originally the nitrogen of the decaying substances was variously combined with carbon, oxygen, and hydrogen, but when it leaves its former arrangement in obedience to the action of decaying bodies *it uniformly adopts one and only one new one.* Every azotized compound exposed to air and moisture *liberates its nitrogen to unite with free hydrogen and form ammonia. This is a principle of fermentation which admits of no exception.* We are acquainted with no instance in which the nitrogen of organic compounds, fermenting under those conditions, combines with oxygen until it have first formed ammonia with hydrogen, but after the formation of ammonia oxides of nitrogen are formed with facility. This is a well-known cause of difficulty in nitrogen determinations in organic analysis, and it brings before us the important fact that before the farmer can obtain any nitrates for his crops he must incur risk of loss by the formation of volatile ammonia. Does it not also press upon him the wisdom of taking all possible precaution to conserve the latter that, by its oxidation in the presence of lime and other alkaline bases, his fields may be supplied with abundance of the former?

All known fixers of ammonia, &c. are too costly for use, and, if they were not, are every way inferior to nature's fixer EARTH. I shall not extend the limits of this paper by a chemical discussion of this topic, but will refer the reader to the experiments by Mr. Thompson and Mr. Way which have been published in the Society's Journal, and to the following from Liebig:—

"The oxides of iron and alumina are distinguished from all other metallic oxides by their power of forming solid compounds with ammonia. The precipitates obtained by the addition of ammonia to salts of alumina or iron are true salts in which the ammonia is contained as a base. . . . . Some varieties of alumina (pipeclay for instance) emit so much ammonia when moistened with caustic potash that even after they have been exposed for two days reddened litmus paper held over them becomes blue. . . . . Soils therefore which contain oxides of iron and burnt (?) clay act precisely as a mineral acid would do if extensively spread over the surface (or among the manure); with this difference, that the acid would penetrate the ground, enter into combination with lime, alumina and other bases, and thus lose in a few hours its property of absorbing ammonia from the atmosphere. . . . . The ammonia absorbed by the clay or ferruginous oxide is separated by every shower of rain and conveyed in solution to the soil."

Having made an extensive series of experiments extending over four years I shall merely give a few of them to illustrate

what I conceive to be the proper mode of fermenting manure.

I. A heap of sods and weeds containing about 40 cartloads was put to rot, and allowed to remain two or three months. There being a large proportion of earth in the heap, it was employed to mix up with the contents of two very large cesspools which received the drainage of eight 10-roomed houses, and had not been emptied for 17 years. The odour given off by the accumulation was most sickening, and large bubbles of gas generated by the decomposing mass were constantly breaking upon the surface of the water. The solid residue was mixed with nearly its own bulk of the soil and sods, and was thus rendered so free from smell as to be carted past a terrace of houses in the daytime without a complaint. About 35 loads of refuse was removed. With this heap was mixed in a few weeks its own bulk of horse, cow, and pig dung which soon formed a black homogeneous mass almost odourless. It gave off no perceptible gas, and proved in the end as powerful a manure as could safely be applied to land. Some York regent potatoes planted with it grew tops nearly 6 feet long with a corresponding crop of tubers, and Early shaws at 2 ft. 6 in. from row to row could not be dug the second week in July without first removing the tops. The men who dug this crop stated that it was the best they ever dug at the time of year.

II. Four cwt. of pigeon dung was mixed with twice its weight of soil and kept for about five months exposed to weather. It was once turned. No smell of ammonia was perceived during that period, nor would test-paper indicate escape of ammonia save when the heap was turned. A very slight odour was then perceptible, and by careful management a feeble reaction could be detected by the test-paper. I believe the influence of this was superior to 4 cwt. of the best guano applied in the usual way.

III. A person in the neighbourhood had accumulated the blood from the public slaughter-houses for many weeks. At the time of which I speak the mass consisted of more than a dozen tons of black coagulum which was putrefying in a hole. The stench given off could be smelt for half a mile in the direction of the wind, and every one was loud in denouncing the effluvia. The most sceptical would have admitted the formation and escape of phosphuretted hydrogen had he been kept a few minutes on the lee side of the mass. I purchased this and had it carted within a hundred yards of a number of good houses. It was placed to the S.W. so that the offensive stench might be borne on the wind to the inhabitants, and was left a day uncovered. Complaints were numerous, threats of legal proceedings were made, and when sufficient attention was thus

roused to call persons' thoughts to the mode of destroying the effluvia a quantity of earth about equal to the blood was thrown over it. The cure was instantaneous, and no further complaint was made though the whole of the stuff was left for a fortnight where it was first placed. No gas was given off which could be detected by smell or test-paper.

IV. From the same person was purchased at the same time about 20 tons of slaughterhouse refuse consisting of the partially digested food taken from the insides of animals which were killed, and of waste pieces of skin, flesh and hair removed in dressing the carcases for sale. This was carted to the same field as the former, and, like it, was left uncovered to arouse attention, which it did most effectually. Several tons of night soil were added to the heap and the whole was covered with earth, when no more annoyance arose from it than from an equal quantity of dry sawdust. As a manure I never saw anything equal it for efficiency.

V. Forty loads of sods from an old pasture were laid to rot and frequently watered with 'steepwater' from a maltkiln. The latter is a substance abounding in nitrogen and earthy salts from the barley. With these were mixed as much cabbage and green refuse as could be accumulated, amounting to about sixteen loads. From this ordinary tests could detect the escape of neither ammonia nor sulphuretted hydrogen. Four tons of waste wool containing a good deal of oil were then added as a body consisting of much nitrogen and sulphur, well known for its generating great heat when moistened, and for the fœtid odours given off during decomposition. The same result being obtained, 13 tons of mixed horse, cow, and pig dung were added, and then, after a short time, about eight tons of nightsoil. The heap now consisted of materials which were as likely to evolve ammonia and give off offensive odours as anything we can conceive. No smell however being perceptible, and no reaction appearing with test-paper, a feather moistened with hydrochloric acid was employed. This was held over all parts of the heap and at the lee side of it and then away from it in the air, but no difference could be perceived in the two cases. It was then taken to the neighbourhood of an *old fashioned manure heap** containing some fifteen loads, when the white wreaths gave a lesson which it may be hoped will be learnt effectually by those whose wealth is thus hourly dissipated.

I have avoided laboratory experiments as much as possible in this essay, because I know the objection which practical men

* Potatoes manured with this heap yielded little more than half the crop of those manured with the other.

entertain to them. But one may be here mentioned in the hope that others will repeat it, because it is more convincing than a thousand arguments.

A quantity of the heap Experiment V. was digested with water and gave a light brownish solution neutral to test-paper. This was carefully filtered twice and then mixed with caustic potash to test the presence of ammonia. None was given off, but a brown flocculent substance collected upon the surface of a perfectly clear white fluid. This was filtered and the brown substance burnt when it evolved ammonia copiously. It also gave off ammonia slowly when exposed to the air.

Here then was nitrogenized matter in the form of as true a salt as the muriate of ammonia which the farmer buys of the manufacturing chemist for manure. Moreover it was so combined that even potash could not expel it. It was perfectly soluble in water and therefore ready for plants to take up as food. In manure thus fermented I have little doubt will be found an adequate remedy for *weak straw* upon well farmed land; and that the economy of nitrogen will lead to an increase of grain can hardly admit of doubt. In short here was what NATURE makes when she decomposes substances in the earth, a perfect manure according to the highest authority.*

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* *Value of Manure of Heap V.*

Experiment I.—Part of this heap was employed for potatoes. Forty pounds weight of "Haigh's seedling" (kidney) potatoes were planted with it April 4th, 1855, 3 feet 3 inches from row to row, and 18 inches from set to set, upon land of fair quality and in good condition.

Under date August 17, 1855, I have this memorandum relative to the crop:—Average yield 31 fold. Sets $5\frac{1}{2}$ packs (of 240 lbs.) each per acre; $31 \times 5\frac{1}{2} = 170$ packs per acre. Present price 10*s*. per pack; produce = 85*l*. per acre. This experiment is not offered for more than it is worth. Part of this large produce is undoubtedly due to peculiarity of management which this is not the place to describe. It may also fairly be doubted how far a crop off five rods of ground will justify reasoning applied to a field or a farm. No account was kept of the quantity of manure applied, though I do not think it was much, if anything, above an average. But even after every allowance I think the most sceptical will admit that the manure employed must have been better than common. Savoys were planted between the rows of potatoes in the last week of June and they are now, October 29th, an excellent crop.

Experiment II.—The following appears beyond objection:—An acre of light land, of medium quality and in fair condition, was ploughed and planted with York regent potatoes, half on the 3rd and half on the 11th of May. The sets were of the ordinary kind purchased as wanted. Drills were made by the plough 2 feet 2 inches apart, and the sets planted about 15 inches from each other in the row. The rows ran east and west. Twelve one-horse cartloads of manure were given to the acre, besides three cartloads of ashes obtained by burning vegetable rubbish. The potatoes were once handhoed and then earthed by the plough July 7th. They were much admired by neighbouring farmers during growth and on the 31st of August were sold upon the land for 20*l*. 5*s*. per acre, to be cleared by September 28th. I regret my inability to learn the exact produce. Several experienced dealers who saw the crop as it was thrown up estimated it at from 72 to 80 packs per acre. This experiment as the complement of the former seems every way satisfactory as to the *quality* of manure treated as recommended.

VI. The account of these experiments would hardly be complete unless it were extended to note the value of green vegetable matter as a manure, and a peculiarity of its fermentation which seems to have been doubted or denied. Ploughing in a green crop is thought to enrich the land *in carbon* by the fermentation in the soil of what is ploughed under. Gathering green vegetable matter into heaps is regarded very much in the light of forming "a carbonaceous residue of decayed plants." Mr. Stephens has some strong remarks of this kind under the head of "composts," and Prof. Johnston appears to lean to the same view. The latter gentleman has however one passage which it is impossible to pass, as a very large number of my own observations are entirely opposed to it. He says "vegetable substances *in general* do not decay so rapidly, *and emit no odour of ammonia when fermenting*." (*Elements of Agricultural Chemistry*, p. 205.) The words "in general" are in italics, and are clearly meant in some measure to qualify what is stated. But, if the passage mean any thing, its signification is that *with very few exceptions* the fact is as stated.

Having considerable doubt of the fact I resolved to test it practically, and have had collections of green vegetable matter made whenever possible. It has been placed in small heaps such as a barrowful, and in large ones of 2 or 3 cartloads, and comprises grass, cabbage, radishes, and weeds of every kind grown in the neighbourhood. I have tested more than fifty heaps composed chiefly of different weeds and in no instance have I failed in getting turmeric paper strongly browned when *held in the vapour* given off by the decomposing substances. The "odour of ammonia" was certainly not perceptible *at a distance* from my one or two barrowsful of weeds fermented in the open air, but neither would it have been from an equal quantity of ordinary manure under the same circumstances. It was however distinctly and easily perceptible if the nose were placed close to that portion of the heap from which a forkful had just been taken, and I am induced to suspect that the want of this precaution led to the statement I have quoted from that justly high authority Prof. Johnston.*

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* *Small Heaps of Weeds.*—I have this year had made from forty to fifty small heaps of weeds of various kinds with a view to ascertain whether from a bushel to a barrowful would *always* give off *sensible* ammonia. In every case I detected it by smell and by turmeric.

Large Weed Heap.—To remove this subject from the domain of nice chemical investigation or delicate manipulation and bring it fully within the cognizance of the illiterate I collected between six and seven cartloads of weeds and placed them to rot upon a hardly-trodden unabsorbent bottom. The unabsorbent character of the base is so essential to perfect success in the experiment, that I would advise those who repeat it to select, if possible, a place which has been puddled.

The weeds were all pulled by hand from among onion crops. They were in full

One experiment upon a larger scale was most notable. Three or four cartloads of waste radishes were placed to ferment and allowed to remain for three weeks, and when they were removed (June 25, 1853) nearly the whole mass was rotten. Upon coming up to the labourer who was set to remove them I was surprised to find him standing back from the heap with his eyes watering and apparently just recovering his breath. My own nose however soon told me the reason, for the quantity of ammonia given off was such that it was impossible to breathe with the head held closely over the heap. One or two other men who smelt the gas believed I had mixed 'hartshorn' with the heap. From no equal quantity of either animal or vegetable matter did I ever observe an equal escape of ammonia.

Unfortunately I am not able to state what other gases were given off. I left the spot to procure the means of testing it, and upon my return had the mortification of finding that the man had made an end of his 'nasty job' and had removed the mass to an adjacent dunghill. I had omitted to tell him to leave it till I came back.†

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growth, but none had flowered or seeded. They were wheeled upon a heap which slightly consolidated it. This heap was not touched till fluid had run from the bottom three or four days, when a hole a foot square was cut in its centre by a spade *nearly* but not quite to the bottom. Next day this hole contained some fluid, and in two or three days almost a gallon at a time could be collected. The smell to leeward now became insufferable even at nine or ten yards' distance. Several labouring men, who had been brought up gardeners and farmers, described it as smelling stronger than any 'ashplace' they ever emptied.[a] A friend (an intelligent amateur farmer) to whom I showed part of a bottle of the liquid could hardly believe it other than an artificial preparation of "stinking fish in stale urine."

One still afternoon I placed some hydrochloric acid in a soup-plate upon the heap, when a wreath of white fume arose, which was easily visible at 200 yards' distance. Two men at work in the next field were attracted by the 'smoke,' and "cou'dn't think how the green lump of muck could catch fire," and they actually laid down their tools to come and see. I subsequently asked them how far off the 'smoke' could be seen? One said half a mile, the other a quarter; and to the latter statement both adhered firmly as being quite within the truth.

This popular mode of exhibiting the subject will probably weigh more with practical men than the most elaborate analysis.

I am not at liberty here to say anything relative to the incalculable damage done by weeds; but it is to be hoped that farmers will draw the inference which it does not seem easy to miss.

I may perhaps be excused for adding a caution to those who feel disposed to investigate this subject for themselves. They should keep as much as possible on the windward side of the heap, and in manipulating with the fluid should choose a place where a draught will carry from them the evolved gases. Notwithstanding every precaution against inhaling the gases given off, I was made ill by them for more than a week, and my eldest child, a boy of seven years of age, was seized with all the symptoms of typhus after smelling (in the open air) the contents of a bottle to which a strong acid had just been added.

† *Radishes.*—An experiment was made this year (1855) to confirm the one above given. The very dry spring was unfavourable for this purpose, as it caused the

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[a] Nightsoil and ashes form one of the principal manures in this neighbourhood.

With a knowledge of these facts I have no alternative but to differ from the high authorities I have named, and may venture to express a hope that chemists will investigate this subject *in the field* and not in the laboratory.

It surely is a significant hint to farmers to accumulate as much of the green refuse of their farms as possible, and to ferment it with so much soil as to save the ammonia and other valuable compounds with which the decaying plants abound.

It has been found that a ton of dry food and straw gives a quantity of farmyard dung which weighs—

When recent	46 to 50 cwt.
After six weeks	40 ,, 44 ,,
After eight weeks	38 ,, 40 ,,
When half rotten	30 ,, 35 ,,
When fully rotten	20 ,, 25 ,,

The natural indolence of men who do not like to be troubled by innovation would explain these figures by the loss of water during fermentation, and so the subject would be dismissed. But when so very much is at stake we earnestly beg men to lay aside the solicitations of indolence and to consider the matter fully. We ask no agreement in our conclusions but such as the truth of experience will warrant, but we do beg earnest attention as a matter of national importance. Professor Johnston, from whom the extract is derived, says "A part of this loss may no doubt be ascribed to the evaporation of a portion of the water of the recent dung; *but the larger part is due to an actual escape of the substance of the manure itself.*" The loss it will be observed is more than 50 per cent. Of this "the larger part" or more than 25 per cent. "is due to an actual escape of the substance of the manure itself," which signifies that a fourth part of every heap of "rotten muck" has been lost by the farmer who went to the expense of making it!!*

formation of an unusual quantity of woody fibre, and thus diminished the proportion of sulphurised and nitrogenised matter, and retarded decomposition; nevertheless when the mass (about three cartloads) was rotting the results were identical with those of last year. The man who removed the half-rotten mass said, "Eh yon things do stink; they fair took my breath when I flung 'em into the cart." If not polite this is certainly emphatic. Some radishes were dug into the land upon which they grew, and examined from time to time. When an individual radish was pulled out of the ground about half decayed, there was no difficulty in detecting free ammonia. By breaking through the envelope of woody fibre and shielding the root from the wind by the hand, the gas given off by the decaying interior would always affect turmeric paper.

* Since the remarks in the text were written I have met with the following in an excellent little elementary work by Prof. Stöckhardt, p. 382:—

"*The formation of Ammonia.*—Put some gluten, some coarse flour or some peas into a flask, pour in some water and connect the flask by means of a glass tube with a second flask filled about an inch deep with water and let them remain in a moderately warm place. Insert also between the cork and the neck of the first

Mulder's formula for albumen is C_{200}, H_{310}, N_{50}, O_{120}, S_2, P_1; Payen's for lignine (straw) is C_{35}, H_{21}, O_{20}, and these two formulæ represent the principal portion of the organic matter which we put to ferment. What wonder then at the escape of carbon which went far to swell the loss sustained by the manure above mentioned, and of all other fermented under similar circumstances? When the offensive odours of putrefaction can be derived from substances existing in such small quantities as sulphur and phosphorus, and when the proportionately scarce nitrogen is given off in such abundance as ammonia that a vessel of hydrochloric or dilute sulphuric acid placed upon a manure heap or in a necessary is soon converted into an ammoniacal salt, there can be no difficulty in apprehending the enormous quantity of carbon which is converted into a volatile oxide to unite with ammonia and rob the individual farmer to benefit we know not whom. Assuredly Liebig's views in regard to the sufficiency of the atmosphere to supply plants with *organic* matter when they are well supplied with inorganic matter by the soil will exempt him from a charge of leaning too much to the economy of our home-made manure. Yet he writes thus: "In a scientific (practical?) point of view it should be the care of the agriculturist so to employ all the substances containing a large proportion of nitrogen which his farm affords in the form of animal excrements that they shall serve as nutriment *to his own plants.* This will not be the case unless those substances are properly distributed upon his land. A heap of manure lying

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flask a strip of lead paper in such a manner that part of it shall hang down into the flask. The following changes will be observed to take place, more rapidly at a warm, more slowly at a cold temperature:—

(*a.*) Bubbles of gas escape from the glass tube into the second flask: they consist of carbonic acid (and some hydrogen) as may be seen by the turbidness which follows on the addition of lime-water.

(*b.*) The lead paper is coloured dark—a sign of sulphuretted hydrogen being generated.

(*c.*) A pungent smell of ammonia is evolved from the liquid standing over the gluten when it is heated with lime or potassa: consequently ammonia has also been formed.

If we compare this process of decomposition with that which takes place on the putrefaction of non-nitrogenous substances we shall observe the following principal difference in the result:—*On the putrefaction of albuminous substances their nitrogen and sulphur (and phosphorus) combine with hydrogen, forming ammonia and sulphuretted hydrogen (and phosphuretted hydrogen).* These aëriform substances are the chief cause of the very disagreeable odour which is given off during the decay or putrefaction of nitrogenous substances, for instance animal substances. During the further progress of this decomposition there is formed also as with ligneous fibre a brown substance resembling humus."

I extract this because the simple experiment given is within the power and means of any farmer however poor or illiterate, and because it really brings before him in a comprehensible form changes which go on daily in his dung-heaps to his serious loss. The man who has but a cottage allotment may find both means and skill to do what is here directed.

unemployed would serve *him* no *more than his neighbours.* The nitrogen in it would escape as *carbonate* of ammonia into the atmosphere, and a mere carbonaceous residue of decayed plants would after some years be found in its place."—*Agricultural Chemistry*, p. 83.

An extreme case often illustrates an argument more powerfully than an ordinary one, and though no person is so foolish as to leave manure till it have diminished to this "small carbonaceous residue," yet it must be remembered that the process which accomplishes such a result *is a gradual one*, and *that every day brings it nearer.* They who lay most stress upon atmospheric carbon admit that an ordinary soil becomes increasingly productive with its increase in carbonaceous matter derived from manure and the remains of plants, *whatever be the cause* of this. Here then is quite ground enough for an appeal to the practical farmer to husband his carbon as well as his nitrogen; or rather in saving the one to prevent loss of the other.

Albuminous substances contain a certain quantity of unoxidized phosphorus* (Mulder) which must enter into combination with some one or more of the liberated elements which abound when these substances are fermented. *With which element* is a question of some moment to the farmer, because salts of this body are certainly among the most valuable substances which he can add to his land as manure. The effects of burnt bones and superphosphate of lime are familiar proofs. If the phosphorus of albuminous compounds unite during fermentation with oxygen as we find it in the ashes of plants it forms phosphoric acid, a non-volatile body of great value as food for plants; *but if with hydrogen* it forms a volatile substance, phosphuretted hydrogen, which will fly off and in the end benefit *some one*, but certainly not the person who has been at the expense and pains of its production.

Popular opinion will no doubt at once join this phosphorus with oxygen and regard any other view with surprise. The common mode of determining phosphorus in plants, viz. by ignition and estimation from the ash as phosphoric acid, would be urged by most persons as conclusive.

But this opinion seems to be taken up without adequate knowledge. That *part* of the phosphorus of putrefying organic compounds unites with hydrogen and forms the volatile body phosphuretted hydrogen is certain. It can be detected even by the ordinary and inexact sense of smell. The fœtor of putrefying albuminous bodies such as blood is due to this gas as well as to sulphuretted hydrogen, and it is doubtful whether *any* organized

* "It has long been known that the protein compounds, of both animal and vegetable origin, contain sulphur and phosphorus in an unoxidized state."—Rose's Paper before the Royal Academy of Berlin. 'Chemical Gazette,' vol. v. p. 158.

substance can putrefy without evolving it. The only question which it appears possible to raise is *how much* is thus dissipated, and whether it be of sufficient practical importance to need a remedy.

That it may be much will I think be admitted by all who weigh the following considerations. First: that phosphorus does not exist in plants merely as the fixed substance phosphoric acid may be shown from the case of coal. I never remember seeing an analysis of coal which included phosphoric acid among its constituents. Professor Johnston indeed in his 'Elements of Agricultural Chemistry,' p. 224, ed. 5, does include phosphate of lime among the substances found in coal ashes, but it seems to be mentioned rather as what *must* or *ought to be* than as *what is.* In a book published recently by a well-known chemist, Dr. R. D. Thompson, under the head of Coal we find these words; "Coal appears to contain a small quantity of phosphoric acid although we might expect it to contain it in greater quantity, if coal is a substance of vegetable origin as is the opinion universally entertained." This may fairly be taken to represent what is known upon the subject. But I have got both phosphuretted hydrogen and phosphoric acid in considerable quantity by the distillation of coal.

Now this portion of phosphorus can hardly exist in coal as *phosphoric acid,* for if it did some of the many able analysts who have sought to ascertain the inorganic substances in coal would have discovered it. But if it do not exist thus in coal neither it would appear *did it in the plants from which coal is formed,* for it is difficult to conceive that the deoxidizing process can have been carried far enough in ordinary bituminous coal (which contains about 10 per cent. of oxygen) for phosphoric acid to have been robbed of its oxygen. The only conclusion therefore to which we can come is that phosphorus existed in the coal plants in a form capable of volatilization, and therefore different from that of its ordinary combination with oxygen as phosphoric acid.

The laws of nature are too fixed to allow us to suspect differences in her processes though thousands of years may intervene between the periods at which we study them, so that we have strong *à priori* ground for thinking that what existed of old exists now. The argument would be incomplete unless the reader were reminded that nascent hydrogen has the power of deoxidizing phosphoric acid, the most stable of the compounds of phosphorus, and of uniting itself with the liberated phosphorus to form the volatile compound phosphuretted hydrogen. If phosphoric acid be placed in a flask with zinc and dilute sulphuric acid the stable compound will be broken up and the volatile phosphuretted hydrogen formed instead. The reader will also

please to bear in mind that this exactly represents the state of things in a manure heap *which abounds in nascent hydrogen*, and therefore what happens in the instance of which we can follow the change will certainly happen in any other instance in which the same conditions are fulfilled.*

* The formation of much phosphuretted hydrogen, and consequent loss during the fermentation of manure, is stated in the text rather as what analogy showed *must be* than as what was *absolutely known*. Up to the time of writing that, I had never met with a satisfactory statement on the subject, and had never made what appeared a perfectly trustworthy experiment. The difficulty of detecting the presence of phosphuretted hydrogen arose from the fact of sulphuretted hydrogen being generated at the same time. By taking advantage of the different solubility of the two gases in water, I have been able to ascertain the copious evolution of phosphuretted hydrogen before the disturbing influence of sulphuretted hydrogen came into play. It is known that water dissolves three times its bulk of sulphuretted hydrogen (Gay Lussac and Thenard), but only an eighth of its bulk of phosphuretted hydrogen. The former gas is therefore twenty-four times more soluble than the latter.

The large weed heap mentioned p. 333 contained much water, and afforded a favourable opportunity for experiment. The test employed for phosphuretted hydrogen was ammonia-nitrate of silver; and where this was affected almost instantly, acetate of lead showed no free sulphuretted hydrogen for days. By adding an acid to the fluid, however, the latter gas could be detected at any time.

The same result was obtained with another weed-heap subsequently, and with several other parcels of decaying vegetable matter.

Barley gives up a large portion of its nitrogen during the process of malting. The steep-water removes much, and the rootlets (cums) much more. This, therefore, was selected as the least nitrogenized form of grain, with a view to investigate the products of its decomposition. It was mashed as for brewing, a portion of the fluid poured off and the rest left to decompose with the grains. Here, while phosphuretted hydrogen was given off in considerable quantity ammonia and sulphuretted hydrogen were retained in solution, and the usual tests could detect neither in the state of gas.

One of our best toxicologists informs me that he has seldom failed to find this gas given off by human bodies which have been disinterred for the purpose of chemical investigation in cases of suspected poisoning. Are we not, then, justified in concluding that while the British farmer is hiring ships to bring him phosphorus from another hemisphere, he is literally wasting at home much of what he thus expensively imports? Countless thousands of manure-heaps, and still more countless 'middens' and 'ash-pits,' in the three kingdoms, are sending forth their phosphorus as a volatile gas, which the winds bear away to distant oceans to advantage races of men who will inhabit lands as yet unformed, whereas by better management nearly or quite the whole of this may be retained at home. Mr. Noad[a] found 57·18 grs. of nitrates, and 26·56 grs. of sulphates per gallon in the water of the well of Highgate churchyard, evidently formed from the

[a] Mr. Noad's figures are—

	grs.
Nitrate of lime	40·12
Nitrate of magnesia	17·06
Sulphate of potash	17·04
Sulphate of soda	9·52
Chloride of sodium	9·63
Chloride of calcium	5·91
Silica	·90
	100·18 grs. per gallon.

We have a further confirmation of this view in the fact that phosphuretted hydrogen is actually generated in the human body from the phosphorus or phosphates of the food, and that the same change goes on in a mass of urine left to putrefy. Mr. Stephens (*Book of the Farm*, vol. i. p. 485, ed. 2nd) has a table (extracted in Appendix) to show the changes which take place in urine when suffered to putrefy for a month in contact with the air. The last line of this table is in such a form as to prevent calculation, and we are therefore obliged to content ourselves with general statements. No thoughtful person however can read it without inquiring what has become of the sulphuric and phosphoric acids expressed on one side by the figures 475 and

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human remains buried around it. But the nitrogen of these nitrates, and the sulphur of the sulphates, were unquestionably given off during decay as *compounds of hydrogen* (viz., as ammonia and sulphuretted hydrogen); and if these suffered oxidation in their passage through the soil, are we not led at once to infer the same of phosphorus? If this be so, we are following an evident direction of nature, when we mix earth with manure, to arrest these volatile compounds in the first instance, till we can bury them in our fields, to be fully prepared for the use of vegetation.

The following extracts appear illustrative of what is advanced above :—

"The common potato, in a state of putrefaction, is said to give out a most vivid light, sufficient to read by. This was particularly remarked by an officer on guard at Strasburg, who thought the barracks were on fire in consequence of the light thus emitted from a cellar full of potatoes."—Lindley, Vegetable Kingdom, p. 621.

The mean of Fromberg's analysis of potato-ash is (Stephens, vol. i. p. 275):—

Potash	55·75
Soda	1·86
Lime	2·07
Magnesia	5·28
Oxide of iron and alumina	0·52
Phosphoric acid	12·57
Sulphuric acid	13·65
Chlorine	4·25
Silica	4·23
	100·18

The explanation of this phenomenon appears to be that the heat of decomposition, confined in the close cellar, rose sufficiently high to inflame the phosphuretted hydrogen given off during its generation. The large percentage of phosphorus shown by analysis will account for the abundance of the gas.

"Dr. Hulme (Phil. Trans. for 1790) establishes that the quantity of light emitted by dead animal substances is not in proportion to the state of putrefaction in them, as is commonly supposed; but on the contrary the greater the putrescence the less light is evolved. It would seem that this element, endowed with preeminent elasticity, is the first to escape from the condensed state of combination in which it had been imprisoned by the powers of life; and is followed, after some time, by the relatively less elastic gases whose evolution constitutes putrefaction."—Ure, Dictionary of Chemistry, art. "Light," p. 584. Edition 4th.

The reader who bears in mind the quantity of phosphorus contained in animal substances and the insolubility of its compound with hydrogen in the water of decomposition, will be able to explain the fact far more accurately than by the imprisonment of light by vital power.

on the other by 364. The history of the missing sulphuric acid is intelligibly indicated by the *one part of sulphuretted hydrogen* found at the month's end, and I suspect the same indication would have been given with regard to much of the missing phosphoric acid if its decomposition did not happen to yield a gas comparatively insoluble, and the analyst had been at all suspicious of its existence. Sprengel (Stephens, i. 484) gives both sulphuretted and phosphuretted hydrogen as products of the fermentation of the food in the bodies of animals, and what differences can be indicated between this and the fermentation of the manure heap, either in the substances fermented or in the modes of their fermentation? *A distinct chemical change takes place in the arrangement of the elements of food which is not required to sustain an animal's vital powers, and the object of that change is the fitting the useless material to become part of other plants; and whether in the body or out of the body the change is the same, and once begun it continues its operation till it attains its end.*

The legitimate object of the farmer is the conversion of all his waste phosphorus into such a state of combination that it may assist to increase his crops, and that state of combination we at present believe to be an equivalent of phosphorus with five equivalents of oxygen. By the common management of his manure he not only in a measure misses this, but actually converts one of its most valuable constituents into a useless and volatile substance which may benefit another when it has suffered oxidation, but which is worthless to himself.

The importance of sulphur in agriculture can hardly be overrated. When we consider that 5 per cent. of all the hair on our cattle and wool on our sheep is sulphur which is all derived from their food, and that no albuminous compounds can exist without it, we are led to a due estimate of its importance in manure. According to received views this body must be combined with three equivalents of oxygen before it is in a form suited for the food of plants, through which it passes before it can be of service to animals.

Sulphur in the state of sulphuric acid has also a high value of an *indirect* kind. It unites with and retains the volatile and valuable ammonia, and yet while fixing it in no degree diminishes its solubility. It also unites with various other bases and forms salts of great agricultural importance.

The note quoted from Rose, p. 337, states that part of the sulphur in albuminous compounds is unoxidized, and that this is so may easily be proved. Dissolve the albumen in potash, add acetate of lead as long as the precipitate formed is redissolved and heat the solution to the boiling point. It instantly becomes

black by the separation of sulphuret of lead. (Liebig.) Berzelius proved that *urine* contains unoxidized sulphur, for after acidulating with hydrochloric acid and precipitating with chloride of barium and then decanting the clear supernatant liquid there still remained in solution a combination of sulphur. Upon evaporating to dryness and incinerating the residuum sulphate of baryta was found.

Whoever has experienced the horrible smell of sulphuretted hydrogen given off by a large heap of fermenting broccoli or cabbage-leaves will be quite ready to think that a very large part of the sulphur contained in the brassica tribe at least is unoxidized, and in the process of decomposition unites with hydrogen and becomes volatile in preference to taking oxygen and remaining fixed. I have several times had an opportunity of testing this upon a neighbouring farm where vegetables were largely grown. From 20 to 30 cartloads of refuse broccoli-leaves was no uncommon accumulation in the spring, and the odour given off would have convinced the most sceptical of the position here taken without any attempt at chemical investigation. I once noticed the same phenomenon in an open field of broccoli belonging to the same farmer. The crop was planted about 18 inches asunder and most of the lower leaves fell off and decayed where they fell. The smell was so offensive as to be a general subject of complaint, and several persons attempted to obtain a mitigation of the nuisance through the authorities.

Putrefying nightsoil is well known to give off a large part of its sulphur as sulphuretted hydrogen, and hydrosulphate of ammonia (*vide* Liebig, *Agricultural Chemistry*, p. 186), and that the same thing occurs to every manure-heap may be proved by any one who will take the pains to collect and condense the fumes which arise and to analyse the product so obtained. I believe that *all the unoxidized sulphur takes hydrogen in preference to oxygen in a manure heap*, but am far from supposing that the loss of sulphur from the formation and volatilization of sulphuretted hydrogen is limited to that; for I believe that *sulphates* are constantly decomposed by the agency of hydrogen which combines with their oxygen to form water and then with their sulphur as sulphuretted hydrogen. That this is quite possible any farmer may easily satisfy himself.

"When a solution of gypsum in water is mixed with a decoction of sawdust *or any other organic* matter capable of putrefaction and preserved in well closed vessels it is found after some time that the solution contains no more sulphuric acid but in its place carbonic acid and free sulphuretted hydrogen, between which the lime of the gypsum is shared. In stagnant water containing sulphates in solution crystallized pyrites is observed on the decaying roots."—*Liebig*, p. 289.

"Wood and mineral coal are always accompanied by iron pyrites (sulphuret of iron) or zinc blende (sulphuret of zinc), which minerals are still formed from salts of sulphuric acid with iron or zinc during the putrefaction of all vegetable matter."—*Ib.*, p. 350.

That this change is not dependent upon close vessels or deficiency of oxygen is proved by the case of the broccoli field above mentioned and by that of heaps of decaying nightsoil.*

The formation of this compound in our manure heaps is doubly wasteful. It robs the farm of sulphur which ought to be in the most suitable form for plant food inasmuch as it has once formed part of living plants; and by its union with the valuable ammonia it actually assists its escape. It is surely matter of no small moment to prevent the formation of sulphuretted hydrogen altogether if possible; and if not then the aim should be to arrest and oxidize it.†

In regard to the *inorganic* part of manure general opinion is pretty accurately expressed by the author who says "the inorganic salts of the urine and of the solid excrements are not essentially altered by putrefaction." But yet some well-known statements ill accord with this. Dr. Stenhouse found fermenting human urine treated with milk of lime to yield a precipitate which when dried at 212° F. contained 40 per cent. of phosphoric acid and organic matter including about 1 per cent. of ammonia. Johnston, p. 189.

In the table quoted in the Appendix we find 180 parts of the salts of cow's urine passed from a soluble to an insoluble condition during a month's fermentation. Now whether we take the analysis of Berzelius which assigns the phosphoric acid of

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* The reader will bear in mind one or two illustrative facts of daily occurrence. A silver spoon in an egg, or a dish of peas, becomes blackened by the formation of sulphuret of silver upon its surface. The same thing occurs when a silver spoon is boiled in a saucepan in which soup is being made in the ordinary way. I recently met with a case in which the gluten of wheat had become so altered by decomposition, that when the flour made from it was boiled as food for a child, it turned the silver spoon with which it was stirred quite black.

† The following, from Turner's 'Chemistry,' p. 691–2, ed. 8, hints at what I have endeavoured to develop:—"In putrefaction the access of air is necessary, at all events to commence the process; and here the elements of the ferment or exciting body probably do contribute, with those of the putrefying body, to form some of the new products, which are very varied. This process, although essentially the same as fermentation, is commonly characterized by the offensive smell of some of the products, among which are ammonia, *sulphuretted hydrogen*, and *perhaps phosphuretted hydrogen*, since those bodies which are prone to putrefaction are commonly compounds containing nitrogen, sulphur, and phosphorus." The writer has not stated his view as to the form of existence of this sulphur and phosphorus, but as he subsequently doubts and appears to disbelieve the presence of unoxidized phosphorus in albumen (p. 1266), we must suppose he considers them as combined with oxygen.

human urine to the bases soda and ammonia, or that of Johnston which distributes it among soda, ammonia, lime and magnesia, we are equally unable to account for the result of Dr. Stenhouse, unless there be a change among the arrangement of the bases and acids of the inorganic salts, and that such a change *did* take place in the case recorded by Mr. Stephens is clear. That *a* change takes place we think the prior portion of this paper will induce to the belief of, but *what that change is* can only be known by *a wide range of carefully conducted analyses* so compared amongst themselves as to show the law which determines what takes place. Giving one or two analyses and reasoning from them would be worse than useless, and I have therefore attempted nothing of the kind. I venture however to state that the Royal Agricultural Society would add another claim to the gratitude of British agriculturists if it would have an extended series of analyses made under its own supervision in order to determine by a wide induction what changes take place in home-made manure with a view to the proper treatment of it. If three analyses be made in each case, 1, of the manure when fresh; 2, at six weeks old; 3, at 12 weeks; I believe the Society will itself discover a substitute for much of the guano now imported, and that a very large sum of money will remain in the farmer's pocket which now flows annually into the Pacific.

Some persons may be inclined to regard Dr. Stenhouse's result as exceptional, and account for the effect of the milk of lime upon the principle of predisposing affinity, such as occurs in the formation of nitric acid from ammonia in the presence of lime, &c. No doubt that principle was active, but so also must it be in the decomposition of straw which abounds in strong alkalis as may be seen from the following table from Johnston:—

A Thousand Pounds of the Ash of the Straw of Wheat, Barley, Oats, Rye, and Indian Corn, have been found to consist of, respectively:—

	Wheat.	Barley.	Oats.	Rye.	Indian Corn.
Potash	125	92	191	173	96
Soda	2	3	97	3	286
Lime	67	85	81	90	83
Magnesia	39	50	38	24	66
Oxide of Iron	13	10	18	14	8
Phosphoric Acid	31	31	26	38	171
Sulphuric Acid..	58	10	33	8	7
Chlorine	11	6	32	5	15
Silica	654	676	484	645	270
	1000	963	1000	1000	1002

It is impossible to reflect upon the liberation of these things from their prior combinations in the straw without admitting their power to exercise an important influence in the process of fermentation, and when to these we add the alkaline bases contained in the excrements themselves we are prepared to regard them as important contributors to the general result.

It is equally impossible not to be struck with the conservative influence of this mineral portion of our dungheaps. Potash, soda, and lime are calculated to unite strongly with and to retain the valuable phosphoric and sulphuric acids; magnesia has the same power, and it can also combine with phosphates to form double salts.

The well known affinity of oxide of iron, silica, and hydrochloric acid for ammonia points out very clearly the important service these substances may render as fixers of that valuable but volatile alkali.

APPENDIX.

Chemical Composition of the Solid and Fluid Excrements of Animals according to Sprengel.—(Stephens's 'Book of the Farm,' vol. i. p. 484.)

1. Vegetable or woody fibre.
2. Wax and resin.
3. Chlorophylle, or the green substance of leaves partly decomposed.
4. Deposited humus.
5. A fatty and oily substance.
6. Mucus.
7. A peculiar brown colouring matter, in the solid excrement of oxen.
8. Vegetable albumen (hardened).
9. Animal gelatine.
10. Animal fibre.
11. Salivary matter.
12. Ozmazome.
13. Hippuric acid.
14. Uric acid.
15. Lactic acid.
16. Benzoic acid.
17. Urea.

(12–17) Originating in the urinary passages.

18. Bilious matter.
19. Bilious resin.
20. Picromel.
21. Oxides of iron and manganese, derived from vegetables.
22. Earths, silica, lime, alumina, magnesia.
23. Salts consisting of mineral acids and bases derived from plants and water.
24. Common salt.
25. Carburetted hydrogen.
26. Phosphuretted hydrogen.
27. Sulphuretted hydrogen.
28. Ammonia.
29. Hydrogen.

(25–29) Products of the fermentation and putrefaction of the food in the bodies of animals.

Comparison of the Composition of Cow's Urine Fresh, and after it has been kept a Month exposed to the Air.—(Stephens, vol. i. p. 485.)

	Fresh.	A Month Old.	
Water in 100,000 parts by weight	92,624	95,442	
Urea along with some resinous colouring matter ..	4,000	1,000	
Albumen	10		
Mucus	190	40	
Benzoic acid (hippuric acid) (Combined with potash, soda and ammonia forming salts.) ..	90	250	
Lactic acid	516	500	loss 16
Carbonic acid	256	165	
Acetic acid	..	1	
Ammonia	205	487	
Potash	664	664	
Soda	554	554	
Sulphuric acid (Combined with soda, lime, and magnesia, forming salts.)	405	338	loss 67
Phosphoric acid	70	26	loss 44
Chlorine	272	272	
Lime	65	2	
Magnesia	36	22	
Alumina	2	0	
Oxide of iron	4	1	
Oxide of manganese	1	0	
Silica	36	5	
Sulphuretted hydrogen	..	1	
Sediment, consisting of phosphate and carbonate of lime, and magnesia, alumina, silica, and oxide of iron and manganese	..	180	
	100,000	99,950	

The occurrence of 516 parts of lactic acid in this table is calculated to shake our faith in it, for Liebig denies the existence of this acid in urine, and the substances grouped under sediment utterly defy calculation. It does not appear what portion of each base is in combination with each acid. I quote it for the remarkable loss of sulphuric and phosphoric acids and for the guide to one loss in the presence of the sulphuretted hydrogen.

XVII.—*On the Retention of Moisture in Turnip-Land.* By Robert Vallentine, Burcott Farm, Leighton Buzzard.

Prize Essay.

The great value of good root crops is now so generally appreciated, that no special pleading is here required to prove the fact. There are few light-land farmers who do not know that root crops form the very foundation of corn crops; and that without turnips less manure would be made, less corn grown, fewer cattle and sheep kept, and, as a natural consequence, less profit realized.

Moist climates, such as those of Scotland and Ireland, stand pre-eminent for producing heavy root crops; that of England may be taken as a medium between a moist and a dry climate

such as exists in the South of France; and we find that the best turnips are grown in those English counties where most rain falls during the summer.

It is far from my intention to draw comparisons—here, at all events—between the respective merits of English, Scotch, and Irish farming as a whole; at the same time, *moisture* is so important an element in the growth of turnips, that it is evident that the English farmer is placed under peculiar disadvantages in this respect. In all but the westernmost parts of England it requires extreme care to raise a crop of turnips much less bulky than what is raised in moister climates with comparative ease.

The year 1853 was unusually dry in Scotland, and the root crops light. It was one season out of many when the fly, so common to English crops, attacked the turnips grown north of the Tweed. The same year was, singularly enough, very wet in many parts of England, and on the driest description of soils the turnip crop was better than usual. *Moisture*, therefore, acts an important part in the growth of roots, and without a certain amount of it it is impossible to succeed.

After these few prefatory remarks, I beg to detail the practice adopted on my own farm; and also to allude to the practices of others, who seldom fail in obtaining a good crop of roots by attending to the *necessity* of moisture, with, of course, liberal manuring, &c.

Sandy, peaty, and limestone soils, all have a tendency to lose moisture quickly after receiving it, in consequence of the rapidity with which filtration and evaporation take place in land of so open and porous a texture.

Peaty soils, when quite dry, imbibe more moisture than any other at first, having somewhat the nature of a sponge; but as they do not retain it well in hot weather, it is necessary to use much care to prevent its loss in spring, as no ordinary summer's rain afterwards seems sufficient to make it wet enough for the purpose of raising a root crop. It is of no use to disguise the fact that most of our best farmers have foul stubbles *occasionally*. There is much more opportunity for cleaning light friable soils in autumn than those of a more adhesive nature. It has been our practice, therefore, to clean all the foul light land in autumn whenever the season would permit, for this particular reason, that when the cleaning has to be done in summer, the land usually becomes so dry in the course of working as to be unsuitable for getting a turnip braird without a heavy *accidental* fall of rain. In the first place, then, all soils which have a tendency to lose moisture quickly should be prepared, as far as possible, for the turnip crop in autumn. When the season does not permit of autumn cleaning, the successful chance of growing a turnip crop

on light land rests upon *early* working in spring. Dry turnip soils should be moved in March, or the beginning of April at the latest; and cleaning, if necessary, should be done as early as the weather and the working of the soil will permit. Clean turnip fallows require very little spring and summer labour, and therefore may remain untouched after their winter fallow till the end of April or beginning of May. One ploughing, or two scarifyings, should generally prove sufficient for dry clean turnip land, but when the land is foul the case is reversed, and the excess of working necessary—plough ploughing, drag dragging, harrow harrowing, &c.—turns the soil so frequently over to a hot sun, that there is no alternative but that the moisture must evaporate in the same way as from wet green grass, which is often turned over to expel the water, and convert the residue into hay.

The next point for consideration is, when cleaning has been neglected in autumn, how to manage it in spring without an injurious loss of moisture.

Some years ago the practice was general, and in some districts is still continued, of ploughing turnip fallows—even clean land—three or four times in spring and summer, for the purpose of pulverizing the soil and making it work well. Such a practice on light soils we do not hesitate to denounce as quite against the economy of labour, and the chance of securing a turnip crop by retaining moisture in the soil. We think that one ploughing in spring is amply sufficient for turnips on light soils. This ploughing should be given in April at the latest; after this the plough should give place to the scarifier, which, if good of its kind, not only pulverizes the soil and brings up the weeds to the surface, but also exposes little or no fresh soil to the action of a drying sun. Scarifying certainly causes dry turnip soils to lose much less moisture than ploughing, and, wherever it is practicable to substitute the one for the other, it should be done.

From trials, I have found that a dry loamy soil will imbibe 50 per cent. of water without dropping; a sandy soil little more than half as much, or 25 per cent. Loam and peat have, from the nature of their particles, great power of imbibing moisture. Sand, pure sand, has comparatively little capillary attraction; and the clear glass-like fragments of which it is composed cannot absorb water: it runs through between them; and in summer, rain either sinks suddenly down, or, in hot weather, evaporates quickly from the surface. It is for such reasons that light sandy soils so soon lose moisture, and require peculiar management.

In wet summers drains placed at 3 feet deep, or any other ordinary depth, run after heavy rains. In dry seasons, such as the last, they do not run at all. It is quite obvious therefore

that when no water runs from drains, and the soil becomes drier, *all* the rain which falls upon such land must evaporate. Indeed it has been found in many parts of England that about three-fourths of all the rain which falls throughout the year is evaporated, and thus only one-fourth part passes through the soil to drains.

The evaporation from the earth's surface is greatest usually in March and April, from the circumstance of wind and sun together having a greater drying power than heat alone, which usually obtains in June and July. During the whole of the spring and summer, however, evaporation takes place with great rapidity, and it is important that dry turnip soils should be worked as little as possible during that period, or the chance of obtaining a crop is hazarded.

Autumn or winter dunging of stubbles has been recommended as tending to retain moisture in soils. We believe from experience that it has that effect, but on light soils, through which rain so readily filters in winter, much of the value of the manure is lost, and other means should be resorted to. On clay and loamy soils, when clean, winter dunging is the best course to pursue in almost every case, taking care, however, not to cart upon the land when wet.

The comparative advantages of growing turnips on the *flat* and on *ridges*, have frequently been discussed; and as the main strength of the argument has generally consisted in showing that the flat system of growing roots was indebted for any superiority it might possess to its better retention of moisture in the soil, I make no apology for entering into the matter here. I have had nearly twenty years' experience in turnip growing, and sometimes it has seemed more advantageous to follow the flat system than the ridge, and *vice versâ.* In moist climates ridges, when formed, leave a kind of watercourse or channel between the artificial heights, which acts most conveniently for carrying the superfluous moisture away, and not only that, but the ridges are left, in the intervals of dry weather, in a proper state for working the land, for horse or hand hoeing, as the case may be. Where, as in Ireland and Scotland, 40 inches of rain fall in a year, with a much less average temperature than in the south and east of England, ridges are decidedly preferable, as the flat surface would usually be a puddle; but the case is completely reversed in the dry districts of England, where little more than 20 inches of rain fall annually. The summer heat is also greater, and of course the *evaporation* is far more than in Scotland or Ireland.

The ridge system of growing roots in any country has the merit of permitting of a better and cheaper cleaning of the land when foul than when roots are grown on the flat.

The *flat system*, however, has a decided superiority in a dry climate by retaining on an average of seasons sufficient moisture in the land to grow a good crop, and for this reason we give the preference to the growth of turnips on the flat generally in England.

Short dung, or "artificials," should be used as manures for turnips on dry land.

Long dung ploughed in, in June, as manure for turnips generally ends in disappointment. First, the manure has not time to decompose; and secondly, it renders light soils too porous, and permits the ordinary fall of rain to evaporate too quickly. Chemists tell us there is much loss by fermenting dung very much; at the same time we know by chemical and practical rule, that there is a loss by applying green dung to a light soil very long before the crop is to be grown. The decomposition of dung in such land is usually rapid. Part is washed downwards into the subsoil by heavy rains, and part is wasted by evaporation into the atmosphere. It is better, therefore, to cover dung-heaps over with soil when in course of decomposition, and just before the turnips are to be sown the rotten dung should be applied. In dry land, when it *is* desirable to grow the roots in "ridges" for the greater facility of cleaning and hoeing early, the ridges ought to be rolled down immediately after being sown, unless the land be such as would bind together and form a hard crust, that the young braird could not get through. Whether turnips on dry soils are grown on the flat or ridge, the process of manuring and sowing should be as rapid as possible over such a breadth as the strength of the farm can manage in a day. Rolling, whether on the flat or on ridges, *always* does good on dry turnip land in dry weather. Young turnips can even penetrate through the track of a cart wheel, notwithstanding the great solidity of the soil.

To retain moisture in dry turnip land it is necessary to plough as seldom as possible, and roll as often as the land will bear it, without *crusting* over the surface. If dung is ploughed in in dry weather for turnips intended to be grown on the *flat*, the same day the land is ploughed it ought to be rolled. If applied in ridges, the ridges should be made, the manure applied, and the ridges again reversed on the spread dung the same day; the seed should also be sown without delay, and if at all practicable the ridges rolled down.

The system practised by many of dunging a great breadth of turnip land at once is highly injudicious on the average of seasons, where it is desirable to *retain moisture* in the soil; and those who follow such a course fail more generally than they succeed in getting a regular plant. It is easy to imagine, and

may frequently be observed, that dry turnip land ploughed up in June, and permitted to lie in a hot sun without rolling, for a week, or weeks together, loses much moisture. The evaporation, as noticed before, is frequently greater in the summer months than the fall of rain, therefore the land may lose by injudicious exposure, with a rough surface, more moisture in a few days than it can obtain from an ordinary fall of rain.

The difference of a day, or even a few hours, in sowing turnips has frequently made the first sowing a much better crop than the last, simply on account of moisture; how much more, therefore, might not a week or ten days' exposure to dry weather affect the value of the crop! It is by no means unusual in the end of April to notice some farmers stirring their *dirty* turnip fallows for the first time after the winter furrow. In such cases, when the land has to undergo repeated ploughings, scufflings, &c., at so late a period of the season, the moisture is lost, and it is a mere chance whether it can be regained in time for the turnip crop.

In the matter of *hoeing* turnips, there is a great diversity of opinion. Some say hoe turnips in dry weather if you want to attract moisture from the heavens by dews; others say by hoeing the drought is let in to the plants, and therefore hoeing is injurious in dry weather. If any hoeing is injurious in dry weather, I think it is horse-hoeing *high ridges*, when the hoe cuts down the sides of the ridges so much as to leave but a narrow strip of earth containing the plants exposed to the heat of the sun on all sides, with scarcely any chance of absorbing dew at night, from the smallness of the horizontal surface exposed, and the sides of the ridges imbibe little or no dew. I am confident, practically, that horse-hoeing high ridges in very hot weather *is* injurious, as the soil in many cases gets quite dry, and the plants for want of moisture turn blue and sickly. With that exception, however, I never saw any injury caused by the use of either horse or hand hoe in dry weather. When once the high ridges are reduced to a comparatively level state by horse and hand hoeing, hoeing then does good in dry weather. It must however be remembered, that there is much difference between turning over a soil to the sun and running a share or other cutting implement below the surface. In ploughing, the land is turned nearly upside-down, a fresh surface is exposed at every ploughing; but in hoeing, the *same soil*, with but little change, remains on the surface. Most people know that the finer a soil is, the more dew does it attract. Gardeners know this well, as they hoe very frequently when there are no weeds to kill. The best farmers know this also. In a word, then, I would say, HAND-HOE without intermission in dry weather to attract

more moisture by dews, but use the horse-hoe with discretion as long as the ridges remain high and the weather dry.

General conclusions.—Moist climates are more favourable for the growth of turnips than dry climates. To preserve the moisture which is so essential to root-crops on light land in a dry climate, foul land should, if possible, be cleaned in autumn or early in spring. Land should be worked as little as possible during the summer months, when the evaporation is usually great. Short dung is most suitable for roots on light soils, otherwise artificial manure. There have been reasons assigned for growing turnips both by the Scotch system of ridges, and also by the flat system. The matter of hoeing turnips has also been discussed, with especial reference to the retention of moisture in the land.

XVIII.—*On the Grubbing up of Woods.* By J. EVELYN DENISON, Esq., M.P.

A FEW years ago there was a great fall in the value of woods in this district, not only as regarded the prices of timber and bark, but of spring wood also, as the cultivation of hops, which had afforded a market for the ash-poles, was generally abandoned.

It became necessary to consider what should be done with the woods. After due inquiry I determined to apply a radical remedy; to grub up a portion of the woods, and convert the land to farming purposes.

The soil is a red clay; the timber, oak of good quality, with an undergrowth of ash and hazel. The adjoining land lets for about 1*l.* per acre.

It appeared, on an investigation of the accounts of past years, that the annual return from the woods did not exceed 7*s.* per acre. There was no doubt, if the expense of grubbing should not prove too great, that the land would yield a far larger rent under cultivation.

My first attempt at grubbing was not successful. The men were new to the work. They did the work ill, and at a cost of not less than from 18*l.* to 20*l.* per acre. The same work which was then done ill at a cost of 20*l.* has since been done well for 6*l.* 13*s.* per acre.

While I was engaged in the early stages of this experiment, I had the good fortune to secure the services of Mr. Huskinson as my agent. Mr. Huskinson had had considerable experience in the grubbing of woods, and was occupying a farm of 500 acres at Epperstone, six miles from Nottingham, part of which had been lately converted from wood to arable cultivation. Mr. Hus-

kinson was well acquainted with the process of conversion, and aware of the value of the land converted. He supplied me with some men who undertook to do for 6*l.* 13*s.* per acre what my unskilled men could not do with any advantage to themselves for 20*l.*; and he furnished me with the results of his own experience in the following paper, which I transcribe :—

"Agreeably to your request, I beg to hand you the following statement of the result of converting wood lands into tillage, and in order to make it clear and definite, I shall give you the actual result of a particular example, that of Brockwood Hills Wood in this parish. This wood comprised 136 acres, and consisted chiefly of oak timber, and ash and hazel underwood. It had been wood for a long period; certainly for 500 years, and probably much longer.

"The stock of oak timber averaged 38 trees per acre, and the average size of the trees was 15 feet each. The underwood was of excellent quality: it had been cut at intervals of 18 years, and being in the vicinity of a good market, realised higher prices than the average of woodlands.

"The soil was a strong red loam of considerable depth, and of good natural fertility. Although the stock of timber was not so great in number of trees, or so large in respect of size, as many of the ancient woods in Notts, yet altogether this wood was, I think, as fine and as profitable a specimen of woodlands as any in the county, and certainly much above the average. In 1840 it was proposed to the owner to stub this wood, and convert it into arable land, and in support of that proposition a careful inquiry was made as to the following points :—

"1. What was the annual value to be expected in perpetuity, from the wood, if continued as wood.

"2. What was the present net market value of the stock of timber and underwood, producing such annual value, supposing it to be stubbed and sold.

"3. What would be the total expense of stubbing, burning, draining, fencing, and preparing for tillage.

"4. What would be the annual value of the land for agricultural purposes, when prepared for cultivation, as arable land.

"The first point, though essential to be known, is ordinarily very difficult to estimate, because in addition to the underwood, which recurring at regular intervals may be exactly valued, there is the question, whether the occasional falls of timber exactly represent the annual growth and increase of timber, or whether they fall short or are in excess of that increase, and trench upon the permanent stock. It is the want of accurate information on this point, which has led to the false and exaggerated notions of the value of woodlands which have hitherto prevailed.

"In the case of Brockwood Hills a fair test existed on this point. The wood was purchased of Lord Howe in 1816, and the whole of the timber was then numbered and measured.

"The timber was again measured in 1840, when it was proposed to stub it, and these two admeasurements gave the means of determining whether the timber felled between 1816 and 1840 fairly represented the growth of that period. It was found that the net annual income derived from the wood in the 24 years, from 1816 to 1840, averaged 70*l.*, being equal to an annual rent of nearly 10*s.* per acre. I may say here that my experience of other woods leads me to the conclusion that 10*s.* per acre per annum is above the net income derived from the average of woodlands in the midland districts of the county.

"The 2nd question.—The present net value of the stock of timber and underwood, was found by admeasurement and valuation to be 7344*l.*, or 54*l.* per acre, and this sum was slightly exceeded by the subsequent sale.

"The 3rd question.—The expenses of stubbing and preparing for cultivation were for each acre as follows:—

	£.	s.	d.
"Stubbing the roots of 38 oak trees at 1*s.* each, being the extra cost above the ordinary price of axe felling	1	18	0
Trenching the ground 10 inches deep, in the winter after felling, and stubbing all the roots of underwood at 2*s.* 9*d.* per 100 square yards, or per acre	6	13	0
Burning all the oak and underwood roots	0	18	0
Spreading ashes after burning, per acre	0	3	0
Draining land 3 feet deep at intervals of 8 yards with pipe tiles	4	4	0
Fencing with double posts and rails, and quick, to divide the land into inclosures of 20 acres each, gates and posts to each field, average per acre	1	17	0
Total cost	15	13	0
"*Credit*—			
After stubbing and preparing at the cost here stated, the owner let the land for one year in allotments for potato planting at 3*l.* per acre, which being double the agricultural value, one half to be set off in deduction of the cost of preparation	1	10	0
Nett cost of preparation per acre	£14	3	0

"The 4th question.—After the first year of potato planting, the land was let as agricultural land to the tenant of the adjoining farm, at 30*s.* per acre, and so continues, which is the answer to the fourth question proposed.

"The result to the owner was therefore as follows:—

	£.	s.	d.
"Annual value of woodland, during 24 years, as before stated	70	0	0
Annual value when cleared and cultivated, thus:—			
Amount realised by sale of the stock of timber and bark, as per statement	7344	0	0
From which deduct expenses of conversion, as per preceding statement, 14*l.* 3*s.* per acre, and for 136 acres	1924	8	0
Surplus capital for reinvestment	5419	12	0
Assuming surplus capital to produce 3½ per cent. in perpetuity, the annual increase from such investment is ..	198	14	0
Add the rent of woodland for agricultural purposes at 30*s.* per acre, for 136 acres gives an income of	204	0	0
	£393	14	0

"This result gives an annual income after stubbing of 393*l.* 14*s.*, against the income accruing from wood of 70*l.*

"Gain of income to the owner, by the operation, of, per annum, 323*l.* 14*s.*

"Although the case here stated, from the value of the timber and the high quality of the land, is somewhat exceptional, yet I believe there are few cases in the county where a pecuniary gain would not result from converting woodland into tillage; and I think it may be laid down as an axiom, that where the stock of wood is sufficient to pay the expenses of clearing, and the land suffi-

ciently fertile to be worth 20*s.* per acre for agricultural purposes, there the growth of wood is a loss to the owner.

"The notion of woodlands being profitable, assumes that the annual growth of wood is equal to the interest of the capital stock plus the rent of the land. But I do not believe that a single instance can be shown of any oak wood, which produces 3 per cent. interest in perpetuity upon the capital stock, and so there is the loss of rent during the entire period of its growth.

"I have the honour to be, &c.

"*Epperstone.*" "T. Huskinson.

This account refers to a transaction as far back as the year 1840. Quite lately Mr. Huskinson has been professionally employed to report upon a proposed operation of stubbing a wood, in support of the application of a life-tenant to the Land Improvement Commissioners. I send an extract from this report, as nothing on this subject more clear and comprehensive can be supplied.

". . . . . . As to the improvements proposed, I have no hesitation in saying that they are desirable, and will be beneficial to the persons interested in the estate, whether as tenants for life or as reversioners. The wood in question, of 82A. 1R. 6P., though of ancient date, comprises very few large trees. It is thickly planted with oak, averaging about 80 trees per acre; the size of each tree averaging about 7 feet. The trees are tolerably healthy in many parts of the wood; but in some parts, owing to the wetness of the land, the growth is not very vigorous. The underwood of ash and hazel is well planted, and produces a fair crop, of good quality, for which there is a considerable local demand. Upon the whole, the wood is in as good a condition, and as productive, as any woodland in the midland counties. I have stated the general returns from similar woodlands in this district to be 10*s.* per acre; and I am of opinion that, with present prices of timber, the wood would not produce a greater nett income in perpetuity than 10*s.* per acre per annum.

"For agricultural purposes the land possesses considerable value. The soil is a reddish loam mixed with marl, upon the red sandstone formation, of good natural fertility, and well adapted for the growth of all the root and cereal crops common to the district. The agricultural value of the land, when cleared of wood and drained, is 30*s.* per acre without buildings, and with suitable buildings upon it 36*s.* per acre. There are several farmsteads in the vicinity of the wood, with which the land might conveniently be occupied, and I do not think it would be desirable to erect buildings for the special occupation of this land. The advantages of converting the woodland into tillage will be fairly shown by the following detailed estimate.

"I estimate the value of the stock of timber and underwood upon the land as follows:—

Timber, 560 feet per acre, equal to 44,800 feet, at 1s. per foot	£2240
Bark, 268 tons, at 5*l.*	1340
Underwood, 80 acres, at 8*l.* per acre	640
Gross value	4220
Deduct expenses of felling timber, peeling bark, and cutting underwood	1008
Nett value to be received from timber	£3212

"The cost of the improvements proposed to be effected under the powers of the Land Improvement Company, and which would be necessary to prepar

the land for tillage after the timber and underwood were felled, I estimate thus :—

"Digging, stubbing, and trenching the land to free it from roots, 80 acres, at 8*l*. 5*s*. per acre	£660
Burning roots, at 21*s*. per acre	84
Draining 80 acres 4 feet deep, and 9 yards apart, with 2-inch pipes and 4-inch mains, at 5*l*. 10*s*. per acre	440
Enclosing land in 4 fields of 20 acres each, at 2*l*. 5*s*. per acre	180
Making necessary farm-roads through the land	150
Total cost of improvement	£1514

"Deducting the cost of these improvements, 1514*l*. from 3212*l*., the nett value to be received from timber, there remains a sum of 1698*l*. as surplus for reinvestment, which, at 3*l*. 10*s*. per cent., will yield an annual income of 59*l*. 8*s*.

"The comparison of the annual value of this estate, if continued as woodland, or converted to tillage, will stand thus :—

"1. As woodland—

	£	*s*.	*d*.
Present rental and full value of 23A. 1R. 13P. of arable land	39	0	0
Annual income from woodland, at 10*s*. per acre per annum	41	0	0
Total annual value	£80	0	0

"2. As tillage—

Income from 23A. 1R. 13P. of arable land, now let for	39	0	0
Increased income from this land by removal of wood, and of injury from game and shade, 3*s*. per acre per annum ..	3	9	0
Income from 80A. 0R. 34P. of woodland when converted into tillage, at 30*s*. per acre	120	6	0
Income from 2A. 0R. 12P. on the north-west boundary of the wood shown on the plan by a red line, which from inequality of surface is unsuitable for tillage, and should remain in wood, at 10*s*. per acre per annum	1	0	0
Annual income from 1698*l*. at 3*l*. 10*s*. per cent., being the surplus remaining from sale of timber and underwood, after payment of all expenses	59	8	0
Total annual value	223	3	0
Deduct present annual value, as above	80	0	0
Amount of improved annual value by converting woodland into tillage	£143	3	0

"I submit this estimate of 143*l*. 3*s*. as the measure of the improved yearly value which will accrue to the owner of the estate by the improvements for which he seeks to obtain the sanction of the Commissioners ; and I do so with the greatest confidence, because I have during the last 10 years cleared more than 500 acres of similar woodland in the neighbourhood of this estate, and have thus tested every item of the calculation by actual experiments, under conditions as similar as distinct cases can well furnish.

"I have the honour to be, &c.,

"*Epperstone, July* 3, 1855." "T. HUSKINSON.

I have myself within the last few years grubbed about 100 acres of wood. The results have varied according to the stock of timber on the ground. They have in no case been equal to the results spoken of in the preceding papers, because in no case

was the stock of timber equal to that in the above-named woods. But in every case the wood upon the ground has defrayed the entire cost of grubbing, draining, and fencing, and has left a surplus varying from 5*l.* to 12*l.* per acre.

The following statement gives the actual produce of timber, poles, kids, stakes, bindings, &c., from 8A. 0R. 22P. of the least productive part of the wood, grubbed in the year 1852:—

		£	s.	d.
Oak timber,	165 trees, containing 606 feet, at 1*s.* 3*d.* ..	37	17	6
	419 oak poles, at 1*s.* each	20	19	0
	280 ash poles, at 4*d.* each	4	13	4
Oak-bark,	9½ tons, at 4*l.* 15*s.*	45	2	6
Bobbin poles,	60 above 15 feet long, at 14*s.* per 100 ..	0	7	0
,,	2160 from 12 to 15 feet, at 12*s.*	12	18	0
,,	5800 from 6 to 12 feet	26	2	0
	60 long stakes, at 5*s.*	0	2	6
Kids,	160 scores, at 1*s.* 4*d.*	10	13	4
Stakes,	35 hundreds, at 4*s.*	7	0	0
Bindings,	160 bundles, at 1*s.*	8	0	0
Cordwood,	28 cord, at 5*s.*	7	0	0
Posts,	95, at 4*d.*	1	11	8
	Gross produce of 8A. 0R. 22P.	182	6	10
	Or, per acre	£22	15	8

Expenses.

	£	s.	d.
Felling timber, 165 trees, 9*d.*, 6*l.* 3*s.* 9*d.*, divided by 8	0	15	6
Cutting underwood and felling poles, 1 man 20 weeks, at 12*s.*, 12*l.*, divided by 8	1	10	0
Peeling 9½ tons of bark, 9*l.*, divided by 8	1	2	6
Stubbing the roots, 2*s.* 9*d.* per hundred yards, or per acre	6	13	0
Burning do.	1	0	0
Draining land	4	0	0
Cost of posts and rails, and quick-fencing	2	0	0
	17	1	0
Balance remaining from the value of wood, after paying all expenses	5	14	8
	£22	15	8
The value of this land cleared and drained might safely be put at 28*s.* or 30*s.* per acre. I put it at the lowest estimate	1	5	0
The interest of the surplus of 5*l.* 14*s.* 8*d.*, at 3½ per cent.	0	4	0
	1	9	0
The value per acre as woodland	0	7	0
Increased value by grubbing wood per acre	£1	2	0

I have said that this return is from one of the worst parts of the wood. Ten acres cleared in 1850 gave a value of timber and underwood greater by 7*l.* per acre than the eight acres here quoted; the mean between these two might give a fair average of

the whole wood, viz., 8*l.* 10*s.*, as the surplus per acre after the payment of all expenses.

The account would then stand thus :—

	£	s.	d.
Value of land for tillage per acre	1	5	0
Interest of surplus of 8*l.* 10*s.* per acre, at $3\frac{1}{2}$ per cent.	0	6	0
	1	11	0
Value of land remaining in wood	0	7	0
Increased value by grubbing per acre	£1	4	0

The prices here given, both for work done and produce sold, are the actual prices paid and received during late years.

At the present moment the wages of day-labourers have risen in this district to 15*s.* per week, and up to 16*s.* 6*d.* for the short days of winter; the cost of stubbing has risen also from 6*l.* 13*s.* to 9*l.* per acre.

At the same time the value of the produce from the land cleared has increased in a far greater ratio. If the expense of grubbing the wood has increased nearly one-third, the value of the wheat-crop, the result of grubbing, has increased nearly one-half.

Besides the improved value given to the land there are collateral advantages which must not be overlooked—the benefit to the adjoining land from the removal of the heavy shade of the wood and the constant dampness which hangs about it, from the admission of the sun, and the free circulation of air, can hardly be over-estimated. The wood which I have removed lay in a long and narrow line along the south border of the estate, and cast its shade over a large extent of arable land. The benefit to this land is not less than from 8*s.* to 10*s.* per acre. It has already quite altered in its appearance, and has become very useful and productive, while before it could hardly be cultivated with profit. It should be added that the fresh-grubbed land will yield a course of corn crops without manure, and a second course with the aid of 2 cwt. of guano per acre—a return which, with prices far below those now prevailing, is equal to the fee-simple value of the land.*

These examples are not proposed as being of universal application. The conditions would vary in every district, and the necessary allowances would have to be made. They are offered as a correct account of what has been done on this estate, and in this vicinity.

J. Evelyn Denison.

Ossington, Newark, Notts,
Nov. 1855.

* My crops of wheat on this land are yielding from 4 to $4\frac{1}{2}$ quarters of saleable wheat per acre in this season of rather indifferent yield, equal in value to 16*l.* and 18*l.*; and these sums may be considered almost as clear profit, the straw and the light corn defraying the expenses of simple cultivation. Thus the contrast is 16*l.* or 18*l.*, the value of wheat, against 7*s.*, the value of wood.

XIX.—*On Agricultural Weeds.* By Professor BUCKMAN, of the Royal Agricultural College, Cirencester.

PRIZE ESSAY.

EVERY one connected with the cultivation of the land, from the amateur with his few yards of flower-garden to the farmer with his hundreds of acres, must be familiar with the term *weed*, as both find that their operations are interfered with to a greater or less extent by the appearance of some plants among the objects they wish to cultivate, which, as interlopers taking up space and appropriating food destined for the crop, have from time immemorial borne the reproachful name of weed, our own word being derived from the Saxon *weod*.

But easy as it is to understand what is meant by a weed, it is curious to mark the varied definitions which have been given of the word by lexicographers and others. Bailey describes it as "any rank or wild plant that grows of itself;" Walker, "a herb noxious or useless;" Maunder, "a wild herb;" while Stephens, in his Book of the Farm, states that "whenever a plant grows where it should not, it is a weed." The latter approaches nearest to an agriculturist's notion of a weed. I propose, however, the following definition, viz., that every plant growing with the crop to its hindrance is a weed. Viewed in this light, a crop cultivated one year, if not all gathered, as potatoes, or shed-seeds, as oats, may spring up as *weeds* the following season, inasmuch as they are now not desired, and would hinder the cultivation of the new crop. It is true that, by adopting this definition, every plant may be a weed, so that in making out a complete list of weeds we should have to tabulate not merely our wild flowers, but many of the cultivated plants also; but fortunately the majority of our indigenous plants, except as occasional visitors, keep aloof from cultivation; whilst others, and by no means a small list, will constantly be found preferring the vicinage of man's daily haunts, and indeed *electing* to grow under agrarian circumstances. All such plants are described in the subjoined table, which is meant to convey information on the following points:—

1st. The natural order to which they belong.
2ndly. Their botanical names, both generic and specific.
3rdly. Their common or local names.
4thly. The soil upon which each species mostly elects to grow.
5thly. Their duration, whether annual, biennial, or perennial.
6thly. Their general habit of growth as affecting agriculture.
And, lastly, General remarks upon their distribution or otherwise.

TABLE I.—AGRICULTURAL WEEDS.

1. NATURAL ORDER.	2. BOTANICAL NAME.	3. COMMON OR LOCAL NAME.	4. SOILS.			
			Sandy.	Clay.	Calcareous.	Loamy.
Ranunculaceæ	Adonis autumnalis	Corn pheasant's eye	..	..	..	—
,,	Ranunculus ficaria	Pilewort crowfoot	—	—	—	—
,,	,, acris	Upright meadow crowfoot	..	—	—	—
,,	,, repens	Creeping crowfoot	—	—	—	—
,,	,, bulbosus	Bulbous meadow crowfoot	—	..	—	..
,,	,, arvensis	Corn crowfoot; hungerweed	..	—	..	..
,,	Delphinum consolida	Larkspur	—	..	..	..
Papaveraceæ	Papaver argemone	Prickly-headed poppy	—	..	..	..
,,	,, hybridum	Round rough-headed poppy	..	..	—	..
,,	,, dubium	Long smooth-headed poppy	..	—	..	..
,,	,, Rhæas	Common red poppy	—	..	..	..
Fumariaceæ	Fumaria capreolata	Fumitory	—	..	..	—
Cruciferæ	Thlaspi arvense	Corn penny-cress	..	..	..	—
,,	Capsella Bursa pastoris	Shepherd's purse	..	..	..	—
,,	Iberis amara	Candytuft	..	..	—	..
,,	Lepidium campestre	Pepperwort	..	..	..	—
,,	Camelina sativa	Gold of pleasure	..	..	..	—
,,	Brassica napus	Narew; wild rape	..	..	..	—
,,	Sinapis arvensis	Charlock (ketlock)	..	—	—	—
,,	,, nigra	Black mustard	..	..	..	..
,,	Raphanus raphanistrum	Wild radish	..	..	..	—
Violariæ	Viola tricolor	Wild pansy	..	..	..	—
Caryophylleæ	Silene inflata	Bladder campion	..	..	—	..
,,	Lychnis dioica	Common campion	..	..	—	—
,,	Agrostemma Githago	Corn cockle	..	..	..	—
,,	Spergula arvensis	Spurrey, perry	—	..	..	..
,,	Stellaria media	Chickweed	..	..	..	—
,,	Arenaria serpyllifolia	Thyme-leaved sandwort	—	..	—	..
,,	,, trinervis	Three-nerved sandwort	—	..	—	..
,,	Cerastium arvense	Corn mouse-ear	—	..	..	—
Lineæ	Linum catharticum	Purging flax	..	—	—	..
Malvaceæ	Malva sylvestris	Common marsh mallow	..	..	..	—
,,	,, rotundifolia	Round-leaved marsh mallow	..	..	..	—
Geraniaceæ	Geranium molle	Soft-leaved cranesbill	..	..	—	—
,,	,, dissectum	Jagged-leaved cranesbill	..	..	—	—
,,	,, columbinum	Long-stalked cranesbill	..	..	—	—
,,	,, Robertianum	Herb Robert	—	—	—	—
Leguminosæ	Ulex Europæus	Furze, gorse, or whin	—	—	..	..
,,	Genista tinctoria	Dyers' green weed; woad waxen	..	—	..	..
,,	,, anglica	Needle green weed; petty whin	—	..	..	..
,,	Ononis arvensis	Rest harrow	..	—	—	..
,,	Ervum hirsutum	Hairy tare	—	..	—	—
,,	,, tetraspermum	Smooth tare	..	—	..	..
Rosaceæ	Rubus	Bramble; blackberry	—	—	—	—
,,	Potentilla anserina	Silverweed	..	—	—	..
,,	Alchemilla arvensis	Corn ladies' mantle	..	..	—	..

AGRICULTURAL WEEDS.

5. DURATION.			6. HABIT OF GROWTH					REMARKS.
Annual.	Biennial.	Perennial.	Upright.	Running above ground.	Creeping under ground.	Climbing.	Deep-rooted	
—	..	..	—	..	..	..	..	In corn fields, often introduced with seed.
..	..	—	—	..	..	..	..	In the corners of fields everywhere.
..	..	—	—	..	..	..	..	General, especially in low damp meadows.
..	..	—	..	—	..	..	..	Common in corn and seed fields.
..	..	—	—	..	..	..	..	Usual in dry upland meadows.
—	..	..	—	..	..	..	..	In stiff soil, especially 'hungry clays.'
—	..	..	—	..	..	..	..	On light sandy soil.
—	..	..	—	..	..	..	..	A common denizen of sandy soils.
—	..	..	—	..	..	..	..	An usual limestone plant.
—	..	..	—	..	..	..	..	Generally marks heavy land.
—	..	..	—	..	..	..	..	A most exact indicator of sandy soil.
—	..	..	..	—	..	..	..	A true agrarian.
—	..	..	—	..	..	..	..	Common on limestones.
—	..	..	—	..	..	..	..	Everywhere.
—	..	..	—	..	..	..	..	Frequent in Berkshire.
—	..	..	—	..	..	..	..	A frequent weed, especially on lime.
—	..	..	—	..	..	..	..	Often too plentiful in flax; introduced with seed.
—	..	..	—	..	..	..	..	Takes the place of charlock in parts of Cheshire.
—	..	..	—	..	..	..	..	Far too common on most soils.
—	..	..	—	..	..	..	..	Often represents charlock, and called by the same name.
—	..	..	—	..	..	..	..	Frequent in corn fields.
—	..	..	—	..	..	..	..	Often abundant in seeds.
..	..	—	..	..	—	..	..	Very frequent on calcareous soils.
..	..	—	..	..	—	..	..	Frequent in corn fields and hedgerows.
—	..	..	—	..	..	..	..	A very usual plant in vetches and flax.
—	..	..	—	..	..	..	..	Very abundant in sandy turnip fields.
—	..	..	—	..	..	..	..	Everywhere in cultivated soil.
..	..	—	—	..	..	..	..	Very common in calcareous soils, often filling up
—	..	..	—	..	..	..	..	the blanks in decaying seeds.
—	..	—	—	..	..	..	..	Common in cultivated soils.
—	..	..	—	..	..	..	..	Common in upland seeds and pastures, so much so as to scour sheep.
..	..	—	..	..	..	..	—	In corners of fields and about the homestead, often
..	..	—	..	..	..	..	—	together.
—	..	..	—	..	..	..	..	All common weeds, especially on calcareous up-
—	..	..	..	..	..	..	—	lands; these often grow very rapidly in decaying
—	..	..	—	..	..	..	..	seeds.
—	..	..	—	..	..	..	..	Frequently a great pest in hedgerows.
..	..	—	..	..	..	..	—	More particularly on sandy heaths.
..	..	—	..	..	..	..	—	Very common in poor stiff land.
..	..	—	..	..	..	..	—	On sandy heaths.
..	..	—	..	..	..	..	—	A good indicator of poor soil.
—	..	..	..	..	..	—	..	A great pest in some wheat fields.
—	..	..	..	..	..	—	..	Generally occurs on clays, whilst the former is more usual on sands.
..	..	—	..	..	..	—	—	The several species are often great pests, especially on poor sands.
..	..	—	..	—	..	..	..	Usual in damp parts of the corn field.
—	..	..	—	..	..	..	..	Very general in upland corn-fields.

TABLE I.—AGRICULTURAL WEEDS—*continued.*

1. NATURAL ORDER.	2. BOTANICAL NAME.	3. COMMON OR LOCAL NAME.	4. SOILS. Sandy.	Clay.	Calcareous.	Loamy.
Onograriæ ..	Epilobium montanum ..	Smooth-leaved willow herb ..	—	..	..	..
Umbelliferæ ..	Conium maculatum ..	Hemlock	—	—	—	—
,,	Petroselinum segetum ..	Corn parsley	..	..	—	..
,,	Carum bulbocastanum ..	Tuberous caraway	..	..	—	..
,,	Bupleurum rotundifolium	Common hare's ear; 'Thoro-wax'	..	..	—	..
,,	Æthusa cynapium	Fool's parsley	..	..	..	—
,,	Ægopodium podograria	Gout weed	..	..	..	—
,,	Pastinaca sativa	Wild parsnep	..	—	—	..
,,	Heraclium spondylium ..	Cow parsnep	..	—	—	..
,,	Daucus carota	Wild carrot	..	—	—	..
,,	Torilis nodosa	Knotted hedge-parsley	..	..	—	..
,,	Anthriscus sylvestris ..	Wild beaked parsley	..	..	—	—
,,	Scandix pecten	Shepherd's needle	..	..	..	..
Lorantheæ ..	Viscum album	Misseltoe	O	n	tre	es.
Rubiaceæ ..	Galium tricorne	Rough-fruited corn bedstraw	..	..	..	—
,,	,, aparine	Goose grass; 'cleavers, clivers'	..	..	..	—
,,	Sherardia arvensis	Field madder	..	..	..	—
,,	Fedia olitoria	Lambs' lettuce; 'corn salad'	..	..	—	—
Dipsaceæ ..	Dipsacus sylvestris ..	Wild teasel	..	—	—	..
,,	Scabiosa columbaria ..	Small scabious	..	..	—	..
,,	Knautia arvensis	Corn scabious	..	..	—	..
Compositæ ..	Sonchus arvensis	Corn sow thistle	..	..	—	—
,,	,, oloraceus	Common sow thistle	..	..	—	—
,,	Leontodon taraxacum ..	Dandelion	—	—	—	—
,,	Lapsana communis ..	Nipplewort	—	..	..	..
,,	Cichorium Intybus ..	Wild succory; chicory	..	..	—	..
,,	Arctium Lappa	Burdock	..	—	—	..
,,	Carduus nutans	Musk thistle	..	..	—	..
,,	,, lanceolatus ..	Spear plume thistle	..	—	—	..
,,	,, palustris	Marsh thistle	..	—	..	..
,,	,, arvensis	Corn thistle	—	—	..	..
,,	,, acaulis	Stemless thistle	..	..	—	..
,,	Carlina vulgaris	Carline thistle	..	..	—	..
,,	Centaurea nigra	Black-head; knapweed ..	..	—	—	..
,,	,, scabiosa ..	Hard-head; great knapweed	..	—	—	..
,,	,, cyanus	Bluebottle	—	..	..	..
,,	Gnaphalium dioicum ..	Mountain cudweed	..	..	—	..
,,	,, uliginosum	Marsh cudweed	—	—	—	..
,,	Petasites vulgaris	Butter bur	—	—	..	..
,,	Tussilago Farfara	Coltsfoot	..	..	—	..
,,	Bellis perennis	Daisy	—	—	—	—
,,	Senecio vulgaris	Common groundsel	..	..	..	—
,,	,, tenuifolius	Hoary ragwort	..	..	—	..
,,	,, Jacobæa	Common ragwort	..	..	—	..
,,	Chrysanthemum Leucanthemum	White ox-eye	..	—	..	..
,,	,, segetum	Corn marigold; yellow ox-eye	—	..	..	—

AGRICULTURAL WEEDS.

5. DURATION.			6. HABIT OF GROWTH.					REMARKS.
Annual.	Biennial.	Perennial.	Upright.	Running above ground.	Creeping under ground.	Climbing.	Deep-rooted.	
..	..	—	..	..	—	..	..	A great pest when it takes to arable fields or gardens.
..	—	..	..	..	..	..	—	Usual only on the margins of fields.
—	..	..	..	..	..	..	—	Often common on calcareous soils.
..	..	—	..	..	..	..	—	Common on chalk. 'Pigs feed upon the root in the fallows at Baldock.'—*Rev. W. H. Coleman.*
—	..	..	—	..	..	..	..	Abundant on chalk, Streatley, Berkshire.
—	..	..	—	..	..	..	..	A common agrarian.
..	..	—	..	..	—	..	..	Often a great pest, especially in pastures.
..	—	..	..	..	..	..	—	A frequent weed on calcareous soils.
..	..	—	..	..	..	..	—	Very unsightly in pastures, and often abundant.
..	—	..	..	..	..	..	—	A common denizen of poor clays.
—	..	..	..	—	..	..	..	Common in calcareous corn-fields.
..	—	..	—	..	..	..	..	Common everywhere.
..	..	..	..	..	..	..	..	A pretty though troublesome weed.
..	..	—	P	aras	itic.			Most frequent in apple and black poplar.
—	..	..	..	..	..	—	..	Too common in corn and flax; much introduced in foreign seed.
—	..	..	..	..	..	—	..	A very troublesome agrarian weed; a pest in hedges.
—	..	..	..	—	..	..	..	Common in calcareous arable land.
—	..	..	—	..	..	..	..	Mostly introduced with seed.
..	—	..	—	..	..	..	..	A large weed, common to stiff poor soil.
..	..	—	..	..	..	..	—	Often very abundant with vetches on lime.
..	..	—	..	..	..	..	—	A common weed in calcareous soils.
..	..	—	..	..	..	..	—	Common in well-manured soil.
—	..	..	—	..	..	..	..	A great pest; usual in beans and barley.
..	..	—	..	..	..	..	..	Everywhere.
—	..	..	—	..	..	..	..	A common garden weed.
..	..	—	..	..	..	..	—	Very common on the oolitic limestones.
..	—	..	..	..	..	..	—	Corners of fields, and frequent in meadows.
..	—	..	..	..	..	..	—	A common corn weed.
..	—	..	..	..	..	..	—	Mostly in hedges.
..	—	..	..	..	..	..	—	Mostly in moist lowland meadows.
..	..	—	..	..	—	..	..	Common in deep poor soils.
..	—	..	..	..	..	..	—	Common in upland pastures on limestone.
..	—	..	..	..	..	..	—	In all wild upland situations.
..	..	—	..	..	..	..	—	Common in pastures.
..	..	—	..	..	..	..	—	A great pest in corn fields.
—	..	..	—	..	..	..	..	A good index of poor sandy soil.
—	..	..	—	..	..	..	..	On all thin upland soils.
—	..	..	—	..	..	..	..	A good index of a damp subsoil.
..	..	—	..	..	—	..	..	By the side of streams; our largest leaved British weed.
..	..	—	..	..	—	..	..	Too frequent, especially in stiff soils.
..	—	..	—	..	..	..	..	Everywhere.
—	..	..	—	..	..	..	..	In all cultivated soils.
..	—	..	..	..	..	..	—	Very abundant in calcareous soils, or on cultivated sands.
..	—	..	..	..	..	..	—	
..	—	..	—	..	..	..	..	A good index of clay.
—	..	..	—	..	..	..	..	An index of rich soil.

TABLE I.—AGRICULTURAL WEEDS—*continued.*

1. NATURAL ORDER.	2. BOTANICAL NAME.	3. COMMON OR LOCAL NAME.	4. SOILS.			
			Sandy.	Clay.	Calcareous.	Loamy.
Compositæ ..	Matricaria chamomilla ..	Wild chamomile	..	..	..	—
,,	Anthemis arvensis	Corn chamomile	..	..	..	—
,,	,, cotula	Stinking chamomile	..	—	..	—
Convolvulaceæ	Convolvulus arvensis ..	Small bindweed	—	—	—	—
,,	,, sepium ..	Great bindweed	..	—	—	—
,,	Cuscuta Europæa	Dodder, 'Devil's guts'	..	..	..	—
,,	,, Epilinum	Flax dodder ,, ...	..	..	..	..
Boragineæ ..	Lithospermum arvense ..	Corn gromwell	..	—	—	..
,,	Lycopsis arvensis	Small bugloss	—	..	..	..
,,	Myosotis arvensis	Corn forget-me-not	..	..	—	..
,,	Echium vulgare	Viper's bugloss	..	..	—	..
Orobancheæ ..	Orobanche minor	Small broomrape	..	..	..	—
,,	,, elatior	Tall broomrape	..	..	..	—
,,	,, ramosa	Branched broomrape	..	..	..	—
Scrophularineæ	Veronica hederifolia ..	Ivy-leaved speedwell	..	..	..	—
,,	,, agrestis	Procumbent speedwell	..	..	..	—
,,	,, polita	Field speedwell	..	..	..	—
,,	,, Buxbaumia ..	Buxbaum's speedwell	..	..	..	—
,,	,, arvensis	Corn speedwell	..	..	..	—
,,	Bartsia odontites	Red Bartsia	..	..	—	—
,,	Melampyrum arvense ..	Purple cow-wheat	..	..	—	—
,,	Linaria spuria	Round-leaved toad-flax ..	..	..	—	—
,,	,, elatine	Sharp pointed toad-flax; 'Fluellen'	..	..	..	—
,,	,, vulgaris	Yellow toad-flax	..	..	..	—
,,	,, minor	Small snapdragon	..	..	—	..
Labiatæ	Mentha arvensis	Corn mint	..	—	—	..
,,	Galeopsis Ladanum ..	Red hemp nettle	..	..	—	..
,,	,, villosa	Downy hemp nettle	—	..	..	..
,,	,, Tetrahit	Common hemp nettle	..	..	—	..
,,	,, versicolor ..	Large flowered hemp nettle ..	—	..	..	..
,,	Lamium amplexicaule ..	Henbit nettle	—	..	..	..
,,	,, purpureum ..	Red dead nettle	..	..	..	—
,,	,, album	White dead nettle	..	..	..	—
,,	Stachys arvensis	Corn woundwort	..	..	..	—
,,	Glechoma hederacea ..	Ground ivy; 'Gill'	..	..	..	—
,,	Acinos vulgaris	Common basil thyme	..	..	—	..
,,	Prunella vulgaris	Self-heal	—	—	—	—
Primulaceæ ..	Anagallis arvensis	Pimpernel; 'Poor man's weather-glass'	..	..	..	—
,,	Primula vulgaris	Common primrose	—	—	—	..
,,	,, veris	Common cowslip	..	—	..	..
Plantagineæ ..	Plantago media	Common plantain	—	—	—	—
Chenopodeæ ..	Chenopodium album ..	White goosefoot; 'Fat hen'	..	..	..	—
Polygoneæ ..	Polygonum convolvulus	Climbing buckwheat	..	..	..	—
,,	,, aviculare ..	Knot grass	..	..	..	—
,,	,, bistorta ..	Bistort; 'Snakeweed'	..	—	..	..
,,	Rumex crispus	Curled dock	..	..	—	—
,,	,, pratensis	Meadow dock	—	—	—	—
,,	,, obtusifolius ..	Round leaved meadow dock	..	..	—	—

AGRICULTURAL WEEDS.

5. DURATION.			6. HABIT OF GROWTH.					REMARKS.
Annual.	Biennial.	Perennial.	Upright.	Running above ground.	Creeping under ground.	Climbing.	Deep-rooted.	
—	..	..	—	..	..	..	..	All occur as agrarians, and usually mark tolerable
—	..	..	—	..	..	..	..	soils; the A. cotula is frequent about manure
—	..	..	—	..	..	..	..	heaps.
..	..	—	..	..	—	—	..	Most frequent in sandy soils, where it penetrates to a great depth.
..	..	..	..	..	—	—	..	Mostly about hedges and gardens.
—	..	..	P a	r a	s i	t i	c.	On clover; mostly introduced with seed.
—	..	..	P a	r a	s i	t i	c.	On flax; always introduced.
—	..	..	—	..	..	..	..	A common corn-field denizen.
—	..	..	—	..	..	..	..	Common, especially in sandy situations.
—	..	..	—	..	..	..	..	Common in corn-fields.
..	—	..	—	..	..	..	..	A common limestone weed.
..	..	—	P a	r a	s i	t i	c.	On clovers, having a bulbous base, into which is
..	..	—	P a	r a	s i	t i	c.	sent a spur of the clover root.
—	..	..	P a	r a	s i	t i	c.	On hemp roots in Norfolk and Suffolk.
—	..	..	..	—	..	..	..	
—	..	..	..	—	..	..	..	Common agrarian weeds, especially in soils that
—	..	..	..	—	..	..	..	have been long in cultivation.
—	..	..	..	—	..	..	..	
—	..	..	—	..	..	..	..	Mostly in upland corn-fields.
—	..	..	—	..	..	..	..	Very common in the Midland Counties.
—	..	..	—	..	..	..	..	Frequent in corn-fields.
—	..	..	..	—	..	..	..	Abundant in corn-fields in the Midland Counties,
—	..	..	..	—	..	..	..	usually growing together.
..	..	—	..	..	..	—	—	Often in hedges and corn-fields.
—	..	..	—	..	..	..	..	Very common in calcareous corn-fields.
..	..	—	..	..	—	..	..	Common in stiff soils.
—	..	..	—	..	..	..	..	Frequent in corn-fields in calcareous soil.
—	..	..	—	..	..	..	..	In sandy corn-fields in Yorkshire.
—	..	..	—	..	..	..	..	A plant of calcareous soils.
—	..	..	—	..	..	..	..	A very common weed on the sandlands of Cheshire.
—	..	..	—	..	..	..	..	A common agrarian plant.
—	..	..	—	..	..	..	..	An abundant garden weed.
..	..	—	..	..	—	..	..	Everywhere in waste places and way-sides.
—	..	..	—	..	..	..	..	Frequent in corn-fields and gardens.
..	..	—	..	—	..	..	..	Very general in old seeds; a common hedge plant.
—	..	..	—	..	..	..	..	A plentiful Cotteswold native on oolite.
..	..	—	..	—	..	..	..	Abundant in old seeds on thin soils.
—	..	..	—	..	..	..	..	Everywhere under agrarian circumstances.
..	..	—	—	..	..	..	..	Common everywhere; in corners of meadows.
..	..	—	—	..	..	..	..	Most abundant on stiff clays, as lias, &c.
..	..	—	—	..	..	..	..	Everywhere; P. major, a large variety, occurs much on limestones.
—	..	..	—	..	..	..	..	In rich cultivated soil; always with turnips.
—	..	..	..	..	..	—	..	Common in cultivated districts.
—	..	..	..	—	..	..	..	A troublesome agrarian weed.
..	..	—	..	..	..	..	..	Occurs in patches in lowland pastures.
..	..	—	..	..	..	..	—	Common in waste places, and amid crops.
..	..	—	..	..	..	..	—	Common in moist meadows.
..	..	—	..	..	..	..	—	Too frequent in waste places and with neglected crops

TABLE I.—AGRICULTURAL WEEDS—*continued.*

1. NATURAL ORDER.	2. BOTANICAL NAME.	3. COMMON OR LOCAL NAME.	4. SOILS.			
			Sandy.	Clay.	Calcareous.	Loamy.
Polygoneæ ..	Rumex hydrolapathum ..	Water dock	..	—	..	..
Euphorbiaceæ	Euphorbia helioscopia ..	Sun spurge; 'Wart wort' ..	..	..	..	—
,,	,, exigua	Dwarf spurge ,, ..	..	..	..	—
,,	,, peplus	Petty spurge	..	..	..	—
Urticeæ	Urtica urens	Small stinging nettle	..	..	..	—
,,	,, dioica	Common stinging nettle ..	..	..	..	—
Aroideæ ..	Arum maculatum	Cuckoo pint; 'Lords and ladies'	..	..	..	—
Asphodeleæ ..	Allium vineale	Crow garlick	..	..	—	—
,,	,, ursinum	Hog's garlick	..	..	—	..
Melanthaceæ	Colchicum autumnale ..	Meadow colchicum	..	..	—	..
Junceæ	Juncus effusus	Common rush	—	..	..	..
,,	,, conglomeratus ..	Round-headed rush	—	..	..	..
,,	,, bufonius	Bog rush	—	—	..	..
Orchideæ ..	Orchis Morio	Common orchis	..	—	..	..
,,	,, mascula	Early purple orchis	..	..	—	..
,,	,, latifolia	Marsh orchis	..	—	..	..
,,	,, maculata	Spotted-leaved orchis	..	..	—	..
Gramineæ ..	Triticum repens	Common couch, wicks, twitch	—	—	—	—
,,	Poa compressa	'Squitch'	..	..	—	..
,,	,, trivialis	Rough-stalked meadow grass	..	..	..	..
,,	Alopecurus agrestis ..	Corn foxtail; 'Black bent' ..	..	—	..	..
,,	Agrostis stolonifera ..	'Squitch, fiorin'	..	..	—	..
,,	Avena fatua	Wild oat	..	—	..	..
,,	,, pratensis	Meadow oat grass	..	..	—	..
,,	Bromus mollis	Soft brome grass; 'Lop' ..	—	—	—	—
,,	,, secalinus	Corn, or smooth rye brome grass	..	..	—	—
,,	,, sterilis	Barren brome grass	..	..	..	—
,,	Aira cæspitosa	Hair grass; 'Hassock or tussac grass'	—	—	—	—
,,	Arundo phragmites ..	Common reed	—	—	—	—
,,	Brachypodium pinnatum	Heath false brome grass ..	..	..	—	..
,,	,, sylvaticum	Slender false brome grass ..	..	—	—	..
,,	Lolium temulentum ..	Darnel	..	..	..	—
,,	Arrhenatherum avenaceum, var. bulbosum .	Bulbous oat-like grass, 'Onion couch'	..	..	..	..
Cyperaceæ ..	Carex	Sedge, carnation grass	—	—	—	—
Filices	Pteris aquilina	Brake, or braken	—	..	..	..
,,	Equisetum arvense	Corn horsetail	—	..	..	..

AGRICULTURAL WEEDS.

5. DURATION.			6. HABIT OF GROWTH.					REMARKS.
Annual.	Biennial.	Perennial.	Upright.	Running above ground.	Creeping under ground.	Climbing.		
..	..	—	..	..	..	..	—	In wet places in lowland meadows.
—	..	..	—	..	..	..	..	These three spurges are exceedingly common where good cultivation prevails, being true agrarian weeds.
—	..	..	—	..	..	..	..	
—	..	..	—	..	..	..	..	
—	..	..	—	..	..	..	..	In gardens and corn-fields frequent.
..	..	—	..	..	—	..	..	In waste places very general.
—	..	—	..	..	..	..	—	A weed in pastures, as its leaves are large, and herbage very acrid.
..	..	—	..	..	..	..	—	A great pest in stiff calcareous soils, as it gives a most disagreeable flavour to the sample of corn.
..	..	—	..	..	..	..	—	A disagreeable weed in pastures.
..	..	—	..	..	..	..	—	Very common to calcareous soils: highly poisonous to cattle.
..	..	—	..	..	..	..	—	Common in moist sandy meadows; the poor sandy meadows in Cheshire are often full of them.
..	..	—	..	..	..	..	—	
..	..	—	—	..	..	..	..	A good indicator of damp soil; is soon removed by draining.
..	..	—	..	..	..	..	—	Very abundant, especially in sterile clay; are not eaten by cattle.
..	..	—	..	..	..	..	—	
..	..	—	..	..	..	..	—	In marshy places, or the damp part of a meadow; destroyed by draining.
..	..	—	..	..	..	..	—	
..	..	—	..	..	—	..	..	Too abundant everywhere.
..	..	—	..	..	—	..	..	Common as a comb in calcareous soils.
..	..	..	..	..	..	..	..	Completely takes possession of the land in *corn-fields* on the oolite.
..	..	—	—	..	..	..	..	A troublesome weed in sterile clays.
..	..	—	..	..	—	..	..	A creeping grass of the comb kind; common to uplands.
—	..	..	—	..	..	..	..	A troublesome weed in stiff clay.
..	..	—	—	..	..	..	..	An unprofitable grass in sterile calcareous clays.
—	..	..	—	..	..	..	..	In all poor soils.
—	..	..	—	..	..	..	..	A grass of the corn-field.
—	..	..	—	..	..	..	..	Common to waste places of the field and garden.
..	..	—	—	..	..	..	..	In all wet pastures.
..	..	—	—	..	..	..	..	Common in fields and hedges in damp soil.
..	..	—	—	..	..	..	..	On calcareous heaths, occurs in tufts; not usually eaten.
..	..	—	—	..	..	..	..	In hedges and by road-sides; also scattered in poor meadows.
—	..	..	—	..	..	..	..	Once a great pest in corn-fields, now comparatively rare; often introduced in foreign flax.
..	..	..	..	..	..	..	..	Common in sandy soil near Cheltenham and Worcester, where it is as carefully picked as common couch.
..	..	—	—	..	—	..	..	Sedges of all kinds are weeds, as being innutritious, and only growing on bad or wet lands; good cultivation soon destroys them.
..	..	—	..	..	—	..	..	Common in sandy soils, increases by a rhizome.
..	..	—	..	..	—	..	..	In sandy corn-fields and gardens; common.

Influence of Soil upon Weeds.—The effect of soil upon the growth of all plants is a matter which is perfectly familiar to every one. It is from this cause that, when wild land is brought into cultivation, its natural plants change. *Chickweed*, sandworts, groundsel, spurge, and dead-nettles, are nowhere found in unbroken ground, but in land newly brought under tillage they soon make their appearance.

But however much land may be tilled in one district, we have in it a different wild flora from that in another — the staple commodity of the soil, whether of sand, lime, or clay, exerting considerable influence. Viewed in this light, the observation of common weeds may be made valuable, as indicating the kind of soil, and leading us to infer different degrees of barrenness and fertility. Our table shows that clay or heavy land is subject to the fewest species of weeds ; and this is found to coincide with everyday observation. If we examine the shales of the Silurian rocks, the clays and shales of the lias, the fuller's earth clay, or the Oxford clay, where these are unmitigated, we shall not only find small cultivated crops, but also few species of weeds, and even these for the most part flourish but badly ; indeed, clays in general are inimical to rich vegetation, both from their mechanical texture and chemical composition ;* the common term "hungry clay" is expressive of its being without the food required by plants.

Next to clays we would instance sandy or silicious soils as producing a scanty vegetation, both as regards crop and weeds ; at the same time there are some species which flourish only on sands ; and the beautiful appearance (as far as colour is concerned) which is given to a sandy corn-field by the red poppy and the bluebottle could not fail to excite the attention of those who may have seen them growing on the tertiary sands of Suffolk, or on the deep sand-beds which fill up the lias basins about Cheltenham and Gloucester, the limits of which in all cases are most accurately defined by an abundance of wall barley.

Calcareous soils for the most part have a very distinctive natural vegetation, and even in cultivation many of its characteristic wild plants cling to it most perseveringly. *Mountain lime-*

* This requires qualification. Clays that are imperfectly drained and badly farmed doubtless produce the scanty vegetation here described, and may not inaptly be termed "*hungry*" in the sense of being deprived of their proper support, whether derived from the atmosphere or the farm-yard. The chemical constitution, however, of most clays, is well adapted for the support of vegetable life, and it should be the farmer's business to alter the mechanical texture, which is the chief cause of barrenness on such soils. I have never yet seen clay thoroughly drained, deeply cultivated, and reasonably well farmed, which did not speedily lose the name of *hungry*, and earn the title of *grateful clay*.—H. S. Thompson.

stone, oolitic limestone, chalk, and *marls,* have a distinctive weed flora in such plants as viper's bugloss, gromwell, ragwort, hardhead, wild parsnep, scabious, succory, and others. Indeed, no soils are more prolific of species of weeds than those of a calcareous nature; and there can be but little doubt that many of the plants that we have tabulated under the head of loam are only found there from the circumstance that all good agricultural loams contain more or less lime.

In the list of weeds which are denizens of loamy soils will be found for the most part the true agrarians, such as chickweed, groundsel, the speedwells, mustards, and goosefoot, all of which most perseveringly track cultivation. Now, as loams—by which we mean good soils—are adapted to the growth of our cultivated crops from the circumstance that their mechanical structure and chemical ingredients are such as crops require for their increase, it is no wonder that such soils should also offer a large list of weeds; and as in such positions weeds, like the crop, perfect all their parts, and bring forth a quantity of seed which appears to be remarkably fertile, we may not wonder that, although there is a constant warfare against weeds in cultivated districts, yet, from the defective modes in which this is too often carried on, they sometimes spread in a most unexpected and unlooked-for manner.

But there appears to be a most important point connected with agrarian weeds, that has been, if not overlooked, at least much neglected, and this mainly from the want of more analyses of weeds, namely, that weeds common to good cultivated soil appear to possess some of the most important chemical principles in great quantities. Hence weeds are a twofold nuisance, as they not only appropriate valuable space, but live upon the fat of the land—both, of course, to the prejudice of the cultivated tribes. This fact will appear obvious from Table II. (p. 370), representing the results of ash analyses of some of our common weeds.

For the results of 1, 2, and 3, in this table, I am indebted to the kindness of my friend Dr. J. Blyth, Professor of Chemistry, Queen's College, Cork. These analyses, to the limited extent to which they have been carried, show that the alkalies and phosphates are abundant in agrarian weeds, which is just what we should expect from our experience of the injury inflicted by them on our cultivated crops. They show us further that allowing such weeds to seed not only causes a perpetuation of their evil consequences, but also tends, in a still larger measure, to the abstraction of some of the most valuable food of plants, especially the phosphates.

TABLE II.—Ash Analyses of Weeds.

	1. Blyth.	2. Blyth.	3. Blyth.	4. Liebig.	5. Liebig.
	Veronica hederifolia.* Stems and leaves.	Veronica hederifolia.* Seeds with capsules.	Leontodon taraxacum.† Seeds without the pappus.	Agrostemma githago.‡ Whole plant.	Chelidonium majus.§ Whole plant.
Silica and Sand ..	3·5	2·7	..	2·4	1·4
Potash	27·4	25·4	21·4	22·9	33·1
Soda	6·3	4·2	2·9	..	..
Lime	32·3	13·2	14·3	29·3	23·4
Magnesia	2·2	4·9	11·8	6·1	5·1
Oxide of Iron	peroxide 3·0	peroxide 1·2	peroxide 2·7	1·2	1·2
Chlorine	7·2	1·0	..	..	..
Chloride of Potassium	..	..	..	7·6	3·4
,, of Sodium	..	..	..	..	..
Phosphoric Acid ..	14·1	44·0	41·9	7·2	15·7
Sulphuric Acid ..	4·0	3·4	4·3	2·4	2·3

THE DURATION OF WEEDS.—On referring to our Table of Weeds, it will be seen that they have been arranged according to their duration of growth, as follows :—

1. Annuals.—Plants which are perfected in the course of a single year, when, bringing forth their seeds, they die.

2. Biennials.—Plants which occupy two seasons for perfecting their seeds, bringing forth stem and leaves the first year, and flowering and seeding the second, and then die.

3. Perennials.—Plants which, after they have perfected their seeds, continue life by means of buds—which are forming during the growth of seeds—for an indefinite period.

It would at first sight appear that weeds of the first kind, though numerous, are not very formidable enemies; but there are circumstances which render them exceedingly troublesome. They produce a great quantity of seed, and that oftentimes so quickly as to cause them too frequently to be neglected or overlooked at the most critical time. Now the seeds of an individual species are often enough for a crop ; but there are many species, which, all conspiring to the same end, make annual weeds formidable ; and the reason why land is not overspread by weeds to a greater extent than is really the case is, that of the numerous seeds ploughed in in tillage many are buried too deep to germinate. We must not therefore suppose that because we kill

* *Veronica hederifolia*, Ivy-leaved Speedwell, a common agrarian.
† *Leontodon taraxacum*, Dandelion, grows everywhere.
‡ *Agrostemma githago*, Corn Cockle, an agrarian.
§ *Chelidonium majus*, Greater Celandine, usually about habitations.

those that do come up before they have seeded that the enemy has been destroyed, for of those that did not germinate for want of air many of them only require to be brought to the surface by a new ploughing to bring them into life. Indeed, seeds of many weeds, as charlock, the speedwells, chickweed, and others, may lie dormant in the soil for incredibly long periods. Even the operation of hoeing stirs up seeds; so that whilst it kills one crop of weeds it tends to the production of another, though much smaller one.

The natural history of biennial weeds is a matter of importance to be studied in estimating their consequences and mode of extinction. An attentive observer will see that they have most of them long tap-roots, as is the case with the following:—*Daucus carota*, wild carrot; *Pastinaca sativa*, wild parsnep; *Conium maculatum*, hemlock; *Carduus nutans*, common musk-thistle; *Carduus acaulis*, stemless thistle; *Senecio jacobea*, ragwort. To which may be added the genus *Rumex;* for, although the species are classed as perennial plants, most of them die after producing seed, which they generally do the second year.

Now the large fleshy roots of these plants are appointed as a store of food, which in them is formed the first year, from which the flower-stalks and seeds of the second year's growth can be perfected. Hence the roots, which are succulent and fleshy at the fall of the year, become spongy and shrivelled as the seeding process advances. Indeed, so perfectly is the seed formed from these tap-roots, that if taken out of the soil before the seed be perfect it will even then become ripe and reproductive. From this it follows that with tap-rooted biennial plants, as also with many of the large-rooted perennials, putting them in heaps as they are gathered and leaving them on the ground does not necessarily destroy the probability of a future crop, as the ragworts and thistles will ripen their seed in such situations, and these, by their wings, may be carried all over the farm. In the case of the docks also, the ripening seeds may be left behind, and thus form colonies for the continuation of the species.

Perennial weeds require accurate observation of their habits, if we would successfully conquer them, as in many of these reproduction and multiplication take place in several ways besides the usual one of seeds. Hence the *Ranunculus repens* (creeping buttercup) and *Potentilla anserina* (silver-weed) send out *scions* which creep above the ground and afterwards root at their extremities, thus forming independent plants, which again, acting like their parents, spread the enemy in an incredibly rapid manner. The *Tussilago farfara* (coltsfoot), *Convolvulus arvensis* (bindweed), *Triticum repens* (couch), and others, increase by a *rhizome*, or underground stem, which buds and roots beneath the

surface, thus causing new plants to be multiplied in a rapid and insidious manner. Others stool out, forming fresh buds or *stolons* around the parent-stem, thus in a single year leaving many shoots where there was but one in its early growth, and this stooling is only aggravated if we should carelessly cut off the crowns of the plants, inasmuch as new heads shoot forth, as seen in the dandelion, hardhead, burdock, succory, and others.

Habit of Growth.—Of course the duration of plants is part of their habit of growth, properly so called, but here we confine the term to those modes of growth, whether of the stems or roots, which would tend to separate them into different groups having distinct agricultural peculiarities. Upon this principle the weeds in our Table have been noted under the following heads:—

a. Plants of an *upright* habit of growth, mostly annual weeds, possessing fibrous roots.

b. Plants of a *running* habit, either simply lying prostrate upon the surface of the soil, occupying much room, or rooting their prostrate branches, and thus forming *scions.*

c. Plants which climb around or cling to other plants, thus suffocating, strangling, or otherwise impeding their proper growth.

d. Plants with large underground stems or deep roots, forming a more or less permanent growth for the sending forth of future buds, all below the ground, being commonly perennial, though for the most part bearing annual stems and herbage.

e. Parasitic plants; those which, having no proper roots of their own, live entirely on the juices of others.

In speaking generally of the above divisions, it may safely be concluded that it is highly important in the study of weeds to examine not only that part which grows above the surface, but the facts connected with those parts which penetrate the soil; for while some weeds may at once be destroyed by the simple process of hoeing, others have only their crowns partially injured, which does not destroy the plant, while some are in this way divided into several independent individuals.

As respects climbing plants, it should be borne in mind that of this small list most are annual, and as they impede the growth of plants by twisting their flexile arms around them, or holding on by their hooks or tendrils, as in the tares, twining buckwheat, and bedstraws or cleavers, they should be destroyed before they grow to any height, which may generally be done in the usual process of hoeing, as they are fibrous-rooted annuals. But there are some twining weeds, especially the bindweeds, that have perennial underground stems, and, as these run deep into the soil, it is out

of the question to effect their destruction during the growth of the crop. The only thing to do is to destroy their shoots, being careful to attack their rhizomes in the fallow. This, indeed, is true with respect to deep-rooted weeds in general—they can only be *crippled* during the growth of the crop, whereas the due preparation of the land should include measures for their *destruction.*

Parasitic Plants.—The growth of parasitic weeds in their earlier stages is a subject still involved in considerable mystery; at the same time there can be but little doubt that the broomrapes and dodders are introduced in the seed: and as there appears, for the most part, far less care taken in the growth and collection of foreign than of our native seeds, it will be found that exotic clover or flax-seed is sure to bring these parasites to a greater or less extent, and so destructive are they to the crop, that occasionally whole fields of clover may be seen greatly injured by the *Orobanche elatior* (tall broomrape) and *O. minor* (smaller broomrape), whilst other fields are in like manner attacked by the *Cuscuta Europæa* (dodder). The seeds of the broomrapes are very small and numerous, and, becoming mixed with the clover-seed, from which it is difficult to separate them, they are thus distributed wherever the seed for the crop is sown, and hence broomrapes will usually be found spread over the whole surface of a clover-field. However, the stem being upright and tolerably conspicuous, it is soon detected. With the dodders the case is very different, as their seed is of tolerable size, so that usually only a few of them would be mixed with the seed for the crop; germination, therefore, would commence at but few places, which we may term centres. Their growth, however, is not upright, the shoots being long and flexile, and they destroy the plant upon which they fasten by sending rootlets into its stems, from every point of contact, which suck up its juices. By these means the parasite extends its own growth still farther, destroying in every direction around the centre from which it started, and spreading itself over a large surface in an incredibly short space of time. Now it is obvious that, in treating these two cases, we must act in accordance with the observed facts. The broomrapes, for example, cannot be hoed, as they attach themselves on the very roots of the clover; and besides, this is not a crop that can be so treated. They can only be destroyed by pulling, and this is easily done, as the bulbous base separates very readily from the clover-root. The dodder must be attacked by destroying it at its centres, as soon as it is observed, by either mowing or pulling, as the case may be; but in no case can we, as honest men—who should do as we would be done by—let the affected crop stand for seed, as is too often done with such crops of clover, inasmuch as on the physiological principle of arrested development tending to

seeding, the quantity of seed may be worth something, even though the herbage be comparatively worthless. As regards dodder on flax, it will, in all cases, be found that the stem is stunted and the fibre impaired.

One other parasite which remains to be noticed, though not commonly viewed as a weed, can yet claim no better distinction or treatment. We allude to the *Viscum album* (misseltoe.) This plant grows abundantly on apple-trees in cider counties, and opinions seem quite divided as to its injurious character; yet, if we examine its mode of growth, and observe how puny and deformed the branch usually is above where the parasite has taken its hold, we may see that the vigour of the tree is impaired by the "sucking its verdure out on't." The discrepancy of opinion would seem to have arisen from the observed circumstance that a young tree which has borne but little fruit before its evergreen patron became attached to it may become a good bearer afterwards, and even older trees often bear the better where the misseltoe flourishes. But this is as fallacious as the seeming prosperity of the spendthrift, who, happy in the presence of his flatterers, forgets that his present pleasures are sapping the foundation of his constitution, and that he is becoming prematurely old. So indeed is it with fruit-trees where the misseltoe takes root, their juices being appropriated to the growth of the parasite. The tree fruits for a time in virtue of arrested development, which must induce early senility, ending in early decay.

On the Extirpation of Weeds.—The extirpation of weeds would appear in *theory* a much easier matter than in *practice* it is found to be, for the seeds of wild plants constituting weeds are so universally distributed, that, though they may differ in kind at different places, yet, wherever a crop will grow, there also will weeds flourish, if allowed. There would also appear to be species of weeds peculiar to certain crops, species which appear in one crop and not in another: the charlock is a familiar example of this, as it will often make its appearance in great quantity after the breaking up of a pasture or old sainfoin ley, where it had not been observed before for years. Evidence of this may also be obtained from the vast quantities of wild plants which spring up in woods after trees and underwood have been removed; so quickly and so abundantly, indeed, as to convince us that their seeds must have lain dormant, only awaiting the required circumstances to vegetate. Newly-formed earthworks frequently cause the sudden growth of wild plants which have never before been observed in the district. Hence, however careful we may be to destroy weeds in one crop, we shall assuredly have some fresh species

with the next, as well as fresh plants of the same, in consequence of dormant seeds having been brought within the power of growth by newly stirring the soil; from which it is obvious that weeds are not to be eradicated by one effort, however vigorous it may be.

The getting rid of weeds would appear to resolve itself into the two following heads:—

1st. *Destroying those already in the soil.*

2nd. *Preventing others being sown.*

The first of these must be considered with reference to those weeds which are already rooted in the soil, that is, weeds of a perennial character, as well as those annual weeds the seeds of which have been scattered at different periods.

Perennial and deep-rooted weeds can only be got rid of by properly preparing the fallows, to which end farm-work should always be got as forward as possible. One of the most common causes of the continuance of weeds is that work is delayed until it is time to get in the seed for the crop, when untoward weather, want of time, or some other cause, prevents the possibility of that thorough cleaning which is necessary to get rid of weeds. *Seed is thus put into foul land, which must wait until a more convenient season for being cleaned.*

In the usual process of arable farming, the preparation of the soil by ploughing, scuffling, harrowing, and exposure to sunshine and drought, clears the land of a great quantity of weeds; but if we observe the depth to which the underground stems of couch, coltsfoot, bindweed, and such-like plants, penetrate, we shall see at once that this is not sufficient to *exterminate the enemy;* but, having done this in the most careful manner, we may observe that there are still spots left here and there in a field where these weeds flourish. Now, it appears to me that the best method of dealing with a case like this is to go carefully over the ground after the crop is removed and dig up the weed-patches with a three-pronged fork. With this implement they can be followed in their direction and depth; and thus, by a simple employment of day-labour, these *isolated nurseries of mischief* may, if not too numerous, be readily, perfectly, and cheaply broken up. Indeed, there is no mode so efficient as this; and, from long observation of the natural history of weeds of this kind in arable fields, I am convinced that more may be done by the fork towards the complete eradication of deep-rooted weeds than by any other means.

There are some of these deep-rooted weeds which are exceedingly troublesome in pastures, such as the stinging-nettle, butterbur, and bistort. These occur in patches, some in the corners of the field, others in wet places, while the bistort will be found

occupying isolated spots in the centres of meadows. These cannot well be attacked by digging them up. The best plan of treating them is to regularly mow them down when their stems grow a few inches above the surface of the ground. The principle upon which this is recommended is, that the leaves are absolutely necessary to the extension of the whole of the parts of a plant; if, therefore, these are continued to be destroyed in proper time, the extinction of the underground stems is ultimately insured; it will not do, however, to leave them until the usual period of mowing, as at that time the plants will have advanced to maturity, and the leaf function have been fully performed. An observance of this law will be of great use in destroying many weeds in situations where the roots cannot be got at: let it simply be borne in mind, as *the leaves are the lungs of the plant, never in such cases to allow the lungs to develop themselves.*

THE PREVENTION OF WEED-SOWING.—Weeds are constantly being sown under many circumstances, the chief of which may be stated as follows:—

Weeds are sown with the seed for the crop.

Weeds are spread over the land by manures.

Weeds are perpetuated by being allowed to seed.

Weeds are disseminated from road-sides and waste land, or from a badly managed farm to a good one, chiefly by "flying seeds."

Sowing of Seeds.—That weeds are perpetuated notwithstanding the most careful preparation of the land by sowing them with our seeds, is a fact too well known to be disputed. Six years ago we saw a field sown with foreign flax-seed which came up full of black mustard—*Sinapis nigra*, much to the injury of the crop: this has ever since been a troublesome weed in the field, and has even been the means of disseminating it over a great portion of a farm on which it was previously almost unknown.

Again, many weeds are sown with clovers, seeds, sainfoin, and the like, which, though they may not make way during the covering of the ground with the crop, may yet appear in some future crop.

From this it follows that too much care cannot be taken to get clean seed, and it wants but little botanical skill to detect the presence of weeds in a sample. Pure or clean seed is even worth paying a greater price for, as the reverse may entail trouble and expense for years. Any mechanical processes, therefore, which can be made available for cleaning seed are well worthy of patronage. A seedsman who will be careful in the preparation and collection of seed deserves the best support. In order also to assist in this

matter, farmers should be particular not *to allow a dirty patch to stand for seed, although it may be " the most profitable thing they could do with it."*

Weeds in Manure.—It is too much the custom to consider that the power of germination of seed is destroyed by decomposition in manure heaps. That some are so when the manure has been thoroughly decomposed there can be no doubt; but many are not, and with those that are the process is too uncertain to be relied upon. We have seen quantities of pulled docks and of crow-garlick thrown upon a heap to decay, and afterwards noticed vetches manured therewith to be full of these troublesome weeds. Neglected manure-heaps are often covered with a profuse vegetation, which *thereon produce enough weed-seeds to stock a farm.* In these cases the plants rendering the original seed were doubtless mixed with the straw of which the manure was made; and yet, notwithstanding the vicissitudes they had to contend with, were not destroyed. Too much care, therefore, cannot be taken to prevent this source of mischief, to which end it will always be found best to burn pulled weeds; and in harvesting corn, docks, thistles, and the like should not be bound up with the sheaves, but, if practicable, left standing, and afterwards destroyed.

Seeding of Weeds.—One of the most fertile sources of the continuation of weeds is that of constantly allowing them to seed on the land. Now, the enormous increase which may result from seeding may be gathered from the following table of observations made upon a few of our common species :—

TABLE III.—Estimation of the probable Power of Increase of Weeds.

Botanical Name.	Common Name.	Number of Flowers.		Number of Seeds each Flower may bear.		Number of Seeds on a single Plant.
Senecio vulgaris	Groundsel	130	×	50	=	6,500
Stellaria media	Chickweed	50	×	10	=	500
Agrostemma githago ..	Corn Cockle	7	×	370	=	2,590
Lychnis dioica	Campion	25	×	137	=	25,137
Papaver rhœus	Red poppy	100	×	500	=	50,000
Sinapis arvensis	Charlock	400	×	10	=	4,000
,, nigra	Black mustard	200	×	6	=	1,200
Galium tricorne	Corn bedstraw	100	×	2	=	200
,, aparine	Clivers	550	×	2	=	1,100
Sonchus arvensis	Corn sow thistle ..	100	×	190	=	19,000
Carduus nutans	Musk thistle	25	×	150	=	3,750
Æthusa cynapium	Fool's parsley	300	×	2	=	600
Ervum tetraspermum ..	Tare	60	×	3	=	180
Daucus carota	Wild carrot	600	×	2	=	1,200
Pastinaca sativa	Wild parsnip	600	×	2	=	1,200

Now, it is not likely that each individual plant would always perfect the quantities of seeds above tabulated; but the list gives a pretty accurate notion of the numbers of seeds which might be perfected under circumstances favourable to their development, and from it will at once be gathered the important practical fact that, allowing for the casualties to which seeds are constantly liable, yet enough would be left, where seeding is allowed but for a single year, to give trouble for many years after.

It cannot be too earnestly urged that weeds be destroyed before their seeds are ripe, or indeed nearly ripe, as the ripening process is often completed by the juices in the stems, especially of pulled weeds: hence groundsel and thistles, when pulled and laid by, as we saw last year, yet ripened much seed; and their *involucres*, opening in the sun, were wafted on the breeze to an indefinite distance; and it should be recollected that one—the primary head—may ripen long before the rest, so that a tolerable weed-growth may follow from a delay which has allowed only this one head to perfect its seed. Each plant of groundsel might in this way be increased fifty-fold, each plant of corn sow-thistle one hundred and ninety-fold, and a single head of musk-thistle may produce an increase of one hundred and fifty-fold.

Hence then weeding should be done as early as possible, either with the horse-hoe, common hoe, or sometimes the Dutch hoe, and, when thus *early* cut down, may safely be left to wither on the ground; but it should be borne in mind that if any individual plants amongst them are shedding their seed at the time and are not taken away, the very hoeing ensures its safe plantation.

It is precisely in this way that coltsfoot is often much increased. The flowers of this plant appear in spring before the leaves. By the time the seed is ripe the leaves become conspicuous; the hoe is then set to work to cut down the latter, by which the ripened seeds are sown, when, if left, they might have flown away to a distance. Now it may be that the roots of the coltsfoot—for it is not destroyed by the hoe—are forked out after the crop has been gathered, but the sown seeds will insure that the pest shall give us some more work to do at a future time. The patches of coltsfoot flowers should therefore be cut down as soon as they appear, and by this means we not only spoil the crop of seeds, but cripple the growth of the plant by cutting off the leaf-buds. Many other instances of a like kind might be adduced, tending to show that a knowledge of the natural history of weeds is of great importance in enabling us to subdue them.

Dissemination of Weeds from Wastes.—This is a matter that requires serious consideration, and, having once obtained correct views upon the subject, should incite to prompt and

energetic action. It is well known that some of the most pernicious weeds are to be found amongst the *Compositæ*, a natural order of plants, to which the *Sonchus*, *Leontodon*, *Carduus*, *Tussilago*, *Senecio*, and *Centaurea* belong. Now in all these plants we may observe that their seeds are crowned with a feathery down—the *Pappus* of botanists—which acts as a tiny parachute, enabling such seeds to be wafted here and there by the slightest breeze, and thus they float for miles; it therefore follows that however particular we may be in trying to subdue them in our cultivated fields, yet waste places and waysides, where many species like to dwell, if not attended to will ever afford a nursery for many of the most objectionable weeds. Waste places, therefore, on every farm—if there be such—cannot too carefully be looked to in this matter: and, if the principle be fully recognised, the keeping roads in order, especially in rural districts, will comprehend *weeding the waysides*. We once saw a farmer employ men, in a not over busy time, in mowing thistles on a good breadth of road running through the middle of his farm, but, unfortunately, the seed was ripe when this was done, and, as the thistles were left where they fell, the dissemination of their seeds was not prevented. This, therefore, is a matter which seems to belong to the overseer of the road, and the plea of idle time should never be recognised.

But unfortunately it is not always that these evils emanate from mere waste places and roadsides. One bad and dirty farmer may *preserve* weeds enough to continue a supply to a wide range of neighbours, in which case it would not seem unreasonable to call upon him to render compensation for damages.

It now remains to glance at some kinds of weeds that have not been much noticed in the former part of this essay, namely:—

Weeds of meadows.

Weeds which impede watercourses.

Weeds of hedge-banks and fences.

Of the many plants which grow in pasture several can be considered only as weeds. Indeed, even the bad grasses, as *Aira cæspitosa* (hassock-grass), *Brachipodium* (false brome-grass), and others, as they encumber with innutritious matter soil which should be otherwise occupied; *Plantago major* and *minor* (plantain), and *Arctium lappa* (burdock), by growing flatly on the ground and preventing the growth of grass, are all weeds. Docks, thistles, and hardhead, by reason of their unfitness for pasture or fodder, are also troublesome weeds. In ridding pastures of weeds, it will be well to bear in mind that the most noxious of them are due to improper cultivation; some show want of draining, and others impoverished soil. Now the first will

disappear by removing stagnant or surface water, and the second by depasturing, dressing with bones and other fertilizers, with the use of the harrow and roller.

Where irrigation can be properly applied it soon makes a marvellous change in the natural vegetation of a meadow. Even in three years we have seen a revolution in the herbage with respect to increased growth, extension of good pasture-herbs, the almost complete annihilation of bad ones, and increase in quantity and nutritive power of the whole. However, there are some weeds in pasture which require early cropping with the scythe, as previously adverted to: whilst isolated plants, as marsh-thistles, burdock, and the like, should be cut down with the hoe or spud.

Weeds in Watercourses.—Much mischief arises from the stopping up and damaging of water-courses by weeds, more especially in trunk-drains, and we have seen a whole system of underdrainage vitiated from a want of attention to this circumstance.

The farmer should be careful to keep his ditches and watercourses free from weeds wherever and whenever they create obstruction; but not only should home water-courses be attended to, but obstructions in brooks and rivers, though often at a distance, are great impediments to the operation of drainage, and the want of removal of weeds may even render an attempt at proper draining futile. There should then, as it appears to us, for the benefit of the whole community, be an officer appointed in every district, whose duty it should be to enforce the keeping of ditches and water-courses clean and free from weeds and other obstructions, and this should be done with as much attention as the surveying of our roads.

The weeds of hedge-banks and fences are innumerable: many wild-flowers, not in our list, by growing in such situations are weeds. Couch, cleavers, bindweed, and bryony are among the most troublesome, especially when they occur in young quicks. To insure the growth of the fence these must be removed, and indeed should never be suffered to make head. This can be done with a small fork, handled with judgment, so as not to disturb the roots of the hedge. By this means we may not only remove the weeds, but the operation contributes to the fertility of the soil, and thus the hedge more quickly overtops what but for this attention would completely smother it. In this case, as in most others, it is safer to burn what we remove than to remove it to the dung-heap or to let it lie about. We knew a farmer who offered his cottagers *3d.* the bushel for weed-ashes; and as a description of the manner in which a cottage family proceeded to make them may be useful and interesting, it is here given.

The refuse of the garden was first put together in a heap, and

covered with turf from the road-side; this, on being fired, burnt in a smothered manner; the children brought all the weeds and refuse they could collect from time to time, and added it green to the rest, and by the occasional addition of turfs a continued smothered fire was kept up for weeks; in one cottage-garden was as much as 50 bushels, and the process still going on. With these ashes the farmer always did well in his turnip-crop; so that not only was an exterminating warfare carried on with our enemies, but they were destined ultimately to be converted into food; and we cannot better conclude this essay than by saying, Always destroy the life and reproductive power of weeds, even by fire, if necessary.

XX.—*On Lamenesses of Sheep and Lambs.* By Finlay Dun, formerly Lecturer on Materia Medica and Dietetics at the Edinburgh Veterinary College.

The sheep of the British Isles are believed to number about 35,000,000; England alone possesses about 27,000,000; Scotland, according to the agricultural statistics of 1854, has 4,787,235, and Ireland, in 1853, had 3,142,656. Calculating the 35,000,000 as worth 30*s.* a-head, the sheep stock of Britain is worth 52,500,000*l.* sterling. The well-being of these flocks is a point of national as well as of agricultural importance, for they not only materially enhance the fertility of the soil and afford a good return to the farmer, but also largely contribute to the feeding and clothing of our population. About 10,000,000 of sheep, weighing on an average 80 lbs. each, are annually slaughtered for food. This furnishes 800,000,000 lbs. of mutton, or on an average rather more than half a pound per day for each individual in the three kingdoms. The mutton at 6*d.* per pound is worth 20,000,000*l.* sterling. Professor Low estimates, that, allowing for the deficient weight of the wool of slaughtered sheep and lambs, each fleece averages 4½ lbs., and the total annual produce of wool will therefore be 157,500,000 lbs. Fixing the value at 1*s.* 3*d.* per lb., the total yearly value of the wool of Great Britain is nearly 10,000,000*l.* sterling. Besides this large home growth about 40,000,000 lbs. are annually received from Australia, and about 10,000,000 or 12,000,000 lbs. from the Cape of Good Hope and British India. Fifty years ago these countries exported scarcely a pound of wool. A hundred years ago the flocks of Great Britain were about half as numerous as they are now.

But profitable and valuable as is the sheep stock of Britain, it might undoubtedly be rendered far more so. Better and more

economical animals might be reared at the same trouble and expense required for the production of the coarse, unsymmetrical, and unprofitable brutes that are still too common. Disease, disappointment, and loss might be greatly diminished by stricter attention to the laws of health. Of late years, indeed, many improvements have been made in the management of sheep, but we are still far short of perfection. We do not always provide adequate wintering fodder for our flocks, we often permit them to fall into miserable condition, and thus shamefully squander food, time, and money. We often fail to provide sufficient shelter and comfort. We carelessly overlook the commencement of diseases and thus allow them to become permanent and incurable. We ignorantly neglect the means of preventing disease, and supinely permit the ravages of many maladies that might be circumscribed. In 1830-31 rot is said to have destroyed 2,000,000 of sheep, and a quarter of a century ago was believed every year to cut off 1,000,000, or about 1-30th of the whole sheep stock of Britain.* The mortality from this disease, although now much reduced, is still very considerable, and in some seasons, as for example in that of last year, entails on the farmer most serious loss. Yet thousands of acres of low-lying undrained land, the well-known cause of all this mischief, still lie in their damp, cold, half-reclaimed state, unfit for profitable cultivation, and pregnant with ill health both to man and beast. Rot, however, is by no means the only disease directly traceable to culpable carelessness and mismanagement; inflammation of the bowels or braxy springs up from neglect to provide sufficient shelter from wet and cold, or from sudden changes of food. Troublesome lamenesses arise every day from driving sheep excessive distances. Foot-rot, the infringement of a simple law of health, counts its victims by thousands. Rheumatism stiffens and disables many a score pastured in low damp meadows. Scrofula, in its hydra forms, decimates the flock debilitated by injudicious breeding in and in. Useless, unprofitable, and unhealthy stock are produced in thousands from ignorance or disregard of the laws which perpetuate in the progeny the characters of the parents. Such illustrations, and they might be multiplied indefinitely, clearly show that a large proportion of the more common and serious diseases of sheep are traceable to causes which might be removed by common care and attention. Prevention is indeed comparatively easy, for sheep are naturally hardy and little liable to disease. When of healthy stock, regularly fed, kept on their native pastures, and moderately sheltered from wet and cold, their ailments are few and simple. The *lamenesses* of sheep, the sub-

* Evidence before the House of Lords, 1833.

ject of the present Report, afford excellent illustration of the truth of the preceding remarks. They are mostly induced by domestication and artificial treatment. They result from the selection of faulty breeding-stock, or from carelessness and mismanagement. In a word, they are chiefly to be ascribed to causes which might be removed: hence it is of much importance that farmers should familiarise themselves with such disorders, and understand especially their nature and causes; for without such information they will be but ill prepared effectually to diminish their prevalence or mitigate their severity.

Before proceeding with the immediate subject of the Report, I have thought it advisable to subjoin in the first place a short description of the anatomy and physiology of the limbs of the sheep.

In the fore-limb there is a scapula or shoulder-blade, a humerus or arm-bone; a radius and ulna, or bones of the fore-arm; a carpus, improperly called the knee, consisting of six small bones, a metacarpal or shank bone, and two digits with three bones each. Behind, there is a femur, or thigh-bone, a tibia and fibula, or leg-bones, a tarsus, or hock, consisting of five small bones, a metatarsal bone, and articulating with its lower extremity two digits with three bones each. The bones above the knee and hock are thickly invested with muscle, but this part of the limb is seldom the seat of injury and consequently requires no detailed notice. The parts below the knee and hock are subject however to various lesions, and hence demand a more lengthened consideration. The shank bones before and behind are so similar that the same description will serve for both. The shank or canon bone, articulating above with the bones of the carpus or tarsus, and below with the two digits, is a dense cylindrical column with a medullary cavity in the centre, peculiarly hard and ivory-like, rounded in front and at the sides and somewhat flattened behind. The front is covered by the tendons which straighten the foot and second phalange; the sides are invested by skin and cellular tissue, while the posterior surface is thickly enveloped by the tendons which flex the digits, and some other structures to be presently noticed. The lower end of this bone presents two articular surfaces for the play of the upper end of the first bone or phalange of each digit, and from this point downwards all the bones in each leg are double. The first phalange or large pastern bone is of the same general form as the shank bone, and about a fourth of its length. It articulates below with the second phalange, small pastern, or coronet bone, which resembles the first, but is only about half its size. It is half enveloped in the horny case of the hoof, and rests upon the posterior part of the last phalange, or coffin-bone, and upon another small

bone behind it—the navicular or shuttle bone. The coffin-bone lying deeply buried in the hoof is triangular, giving to the horny covering its characteristic shape. The abutment of the small pastern comparatively far back upon the coffin-bone imparts to the pasterns of the sheep their peculiar upright appearance.

We pass over the several muscles in the upper part of the limbs employed in flexion and extension. To describe them without diagrams would be difficult and uninteresting. The flexor tendon of the foot situated on the posterior part of the limb arises in the fore leg from the back part of the humerus, in the hind from the back part of the femur. A little above the knee it becomes double. The outer part is flattened and forms a sheath for the inner. At the end of the shank-bone both tendons bifurcate, a division going to each of the digits ; they are inserted into the second and third phalanges. The extensors of the foot arise from and are inserted into the same bones as the flexors, but occupy the front instead of the back of the limb. Two check ligaments pass from the bones, are fixed into the flexor tendons of each limb, and prevent over-extension. When the tendon is stretched to a certain extent the check ligaments attached to it come into play, and from their other end being fixed into the unyielding bone counteract undue extension. The suspensory ligament arising from the head of the shank-bone and passing in front of the flexor tendons to the pasterns below also aids these check ligaments in preventing over-extension. Besides these, a strong ligamentous band connects the upper ends of the coffin-bones, retaining the digits in apposition. This beautiful mechanism of tough chords is constantly lubricated by actively secreting pouches, or bursæ, through which they pass, and which are especially well developed where the tendons are exposed to friction in passing over a bony prominence or playing over a frequently-moved joint. So exquisitely are the several parts of this locomotive apparatus adjusted to each other, and so effective the many adaptations for gaining strength, that accidents and injuries are exceedingly uncommon. The fact too of sheep being seldom exposed to severe over-exertion also renders them less liable than many other animals to ligamentous or tendinous lesions.

The skin investing the leg is thick, and ought to be well covered with hair, which becomes short and brush-like behind. It moves freely over the subjacent textures, being loosely attached to them by a thick layer of cellular tissue. It consists of two strata : an insensible non-vascular epidermis or scarf-skin made up of flattened cells and scales, and covering the deep stratum, dermis, or true skin, which consists of fibrous tissue with numerous blood-vessels and nerves. This layer produces the hair, which is but an altered form of the epidermal covering. Imbedded in its structure

are numerous small glands formed by involutions of the skin, and secreting an oily matter for its lubrication. These oil glands are particularly numerous about the fetlocks and pasterns. They especially abound between the digits and in an involuted pouch of skin called the biflex canal situated in the upper part of the interdigital space. This canal is enveloped in cellular tissue, and measures about an inch in length. Its orifice readily admits the point of a large stocking wire; it widens internally, curving backwards and upwards, and ends in a blind pouch. A number of hairs project from its orifice and an unctuous secretion oozes from it. The number of sebaceous oil glands which the cavity contains shows that its chief function is the elaboration of a lubricant oily fluid for obviating friction and keeping the skin soft, pliant, and protected from moisture. Investing the coffin-bone, the deep layer of the skin becomes thickened, forming round its upper part a transverse vascular ring, from which numerous sensitive leaves, or laminæ, pass downwards to the toe. On the lower or sole surface of the bone these laminæ break up into numerous minute villous processes. Investing these vascular sensitive laminæ, and curiously dovetailed into them, lies the tough, insensible, horny hoof, corresponding exactly with the scaly insensible epidermis, of which it is but an expansion and modification. On the outer and anterior part of the hoof the horn is hard and brittle; on the posterior and inner parts soft, thick, and elastic. The two horny projections behind the fetlock-joint closely resemble the hoofs in structure. Externally the horny matter is tough and firm and of a conical shape. Fitting into each cone is a mass of cellular tissue and fat, loosely connected with the tendons below, and joined to its fellow by a fibrous band. These two elastic pads act as buffers in obviating concussion, and by their horny coverings give an additional means of support and prehension.

The limbs are abundantly supplied with blood. The large arteries from above after giving off many branches terminate in two principal trunks, one of which supplies each digit. These, after many subdivisions, terminate in minute tubes which constitute the great bulk of the sensitive laminæ and supply them abundantly with blood. The veins, returning the blood from these terminal ramifications, proceed up the limb in the same course as the descending arteries. To make up for the blood having to rise against the force of gravitation the veins are twice as numerous as the arteries. The nerves follow the same course as the vessels, and endow the vascular parts with acute sensibility.

Sheep are not subject to such numerous or complicated lamenesses as the horse. They are not subjected to violent or sudden

over-exertion, and consequently enjoy almost total immunity from strained tendons, bursal enlargements, and inflamed joints—affections which prevail amongst horses to a ruinous extent. But comparatively few and simple as are the lamenesses of sheep, they are less generally understood and rationally treated than those of the horse. They often continue for some time unperceived, owing to the culpable neglect of shepherds, or the wide extent of pastures. They are apt to be lightly regarded, on the plea that a sheep, though permanently lame, may still carry mutton and wool. They often receive little examination and study, and, from the small value of the animal, are frequently consigned to the butcher instead of the practitioner.

Lameness amongst sheep and lambs chiefly results from fractures, rheumatism, paralysis, scrofulous swellings and rickets, black-leg, tumours, and bursal enlargements, or from foot-rot, murrain, or other affections of the feet. I shall describe these injuries and diseases in the order in which they are mentioned, referring especially to their nature, symptoms, causes, and treatment, as well as to the means to be adopted for their prevention.

Fractures.—Sheep are not nearly so liable to fractures as men, dogs, or horses. Sometimes, however, they get their legs entangled in a gate or hurdle ; they are tumbled into a ditch by some ill-broken or ill-managed cur ; or, more commonly, they receive a blow from a stick or stone, and the limping gait discovers a "broken leg." The upper bones in both the fore and hind limbs are abundantly covered with muscle, and hence effectually protected from injury. The tibia, or bone immediately above the hock, is sometimes fractured, occasionally involving the hock joint. But the canon or shank bones are most liable to this accident, which is frequently produced by a blow upon their anterior or lateral surface, where they are invested by little else than skin. The fractures are generally simple, and without much displacement. Compound fractures—that is, fractures in which the broken ends of the bone protrude through the skin—are uncommon.

The treatment consists in bringing the parts gently and speedily into accurate apposition, retaining them there by a well-tarred piece of stout cloth rolled repeatedly round the limb, which ought further to be supported by flat slips of wood secured by a light well-adjusted bandage. This must not, as is sometimes the case, be so tight as to stop the circulation. Unless where there has been much injury of the contiguous soft parts, the inflammation speedily abates, and reparation commences in a day or two. A granular fibrine-like lymph is poured into the breach. This lymph is converted into a cartilaginous basis, similar to that

from which the bones are developed in the fœtal state. Minute vessels shortly shoot into it, rendering it ruddy, firm, and elastic. By and by, earthy matter is laid down—the cartilage becomes ossified. But the exudation matter is poured out, hardened, and ossified, not only between the severed edges of the bone, but also extending between the periosteum and outer surface of the bone for a little way above and below the fracture—thus forming an encasing ring for the strengthening and support of the mending bone, and preventing the displacement which the slightest motion would otherwise produce. Is not this a most beautiful and bountiful provision of nature? The broken bones of the lower animals, thus held together and strengthened by "ensheathing callus," make a safe and speedy union, and suffer comparatively little from the motion to which, during recovery, they are necessarily subjected. But nature, ever bountiful, is never lavish. She denies the encircling callus in most fractures of the human bones, but endows man with reason, and leaves him in this, as in other matters, more dependent than the lower animals upon the assistance of his fellow mortals. But the supporting callus, when really necessary, is freely given. The ribs of man cannot, like the other bones, be kept at rest. Respiration cannot wait till bones unite ; and here, accordingly, "ensheathing callus" is poured out, helping and hastening the process of repair. Again, where frequent movements have frustrated the normal union of broken parts, nature occasionally, even with other of the bones of man, makes use of this simple and beautiful means of retaining the parts in apposition and accomplishing their union.*

Rheumatism.—Most of the domesticated animals are subject to rheumatism, and it exhibits a great similarity in all of them. It is a blood disease, characterised by the accumulation of acid matters in the vital fluid. The accompanying fever is generally acute. The inflammation attacks particularly organs of a fibrous structure, and manifests a strange disposition to flit from one part to another. Amongst sheep it frequently affects the muscles of the back, involving especially their tendinous sheathing. It is accompanied by much pain, great stiffness, and unwillingness to move, with all the symptoms of acute fever, namely, a hot mouth, cold extremities, a firm, hard, and somewhat accelerated pulse, with quickened breathing and arrested secretion. In fact the animal has lumbago. After a few days the malady not unfrequently changes its site, the muscles about the neck and shoulders become involved, whilst those originally affected are much relieved. Again the symptoms will abate, when suddenly the

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* See 'Lectures on Surgical Pathology,' by James Paget, vol. i. p. 251.

wandering inflammation seizes some joint which may have previously escaped, but which now becomes hot, tender, and intensely swollen. In fatal cases death results from exhaustion caused by the excruciating pain, or from interference with the action of the heart, induced by the inflammation affecting the fibrous structure of its valves and investing membrane. Occasionally the patient dies in a week or ten days; more commonly, however, the disease assumes a chronic type, and involves some of the larger joints with the neighbouring tendons. The inflammation proceeds leisurely with its work. The vascular sensitive synovial fringes at first become red and angry-looking; they pour out an abnormal secretion of synovia, causing much distension of the joint and acute pain; they gradually become thickened and infiltrated with lymph. The fibrinous exudation is also abundantly laid down within the joint, as well as in and about the ligaments and tendons. These, from the divergence of their fibres, are much thickened. Sometimes the cartilage suffers, its substance being softened and removed. The periosteum, or fibrous membrane investing the bones, also participates; its vascularity increases, and exudations of lymph separate it from the bone, inducing thickenings and hard swellings. Indeed bony matter is sometimes thrown out so abundantly about the joint that its motions are prevented by anchylosis. The muscles, on account of the limb being used as little as possible, gradually waste. Suppuration does not affect the rheumatic joints of men or horses, but amongst sheep the deposits of lymph occasionally degenerate into pus, while the skin softens and ulcerates, making way for the outward passage of the pent-up matter. Rheumatism often affects ewes shortly after the removal of their lambs, and when turned upon damp luxuriant pastures. In such cases the affection of the joints and muscles is complicated by inflammation of the fibrous structure of the udder, causing much febrile action, and leading sometimes to the destruction of large portions of the udder. Early lambs dropped in cold exposed situations frequently become the victims of rheumatism. From the depressing effects of cold, they are often found lying quite stiff, and almost *in extremis.* The administration of a dessert spoonful of brandy with a little ginger, proximity to a good fire, and friction of the limbs, will, however, usually restore the ebbing flood of life. Until the little creatures gain strength to resist the cold, which they do astonishingly soon, they should remain in a sheltered situation, to which, indeed, all the ewes should be transferred as they approach lambing time. This simple precaution prevents much sickness and loss both of lambs and ewes. Even in spite of precautions, delicately-bred lambs are occasionally subject to rheumatic swellings of the joints, causing much stiffness and

inability to use the affected part. One limb may be attacked, and for a time remain very painful, but, as in adults, the complaint is very apt to migrate, attacking now the shoulders, now the loins, and sometimes all four legs together.

Rheumatism appears to depend upon the accumulation in the blood of noxious acid matters. These may be generated in various ways, but most commonly result from the retention of excrementitious products. Hence any circumstances interfering with or arresting the natural processes by which the blood is purified—anything checking the functions of the skin, kidneys, or bowels, may become a cause of rheumatism. In this way, damp cold air, sudden chills, undrained pasturages exert their injurious influence. They are especially powerful amongst young, delicate, or pampered animals, and in the progeny of those that have been subject to the complaint. Such animals do not actually inherit the disease, but they inherit a strong tendency to it, rendering them prone to suffer from causes which would have no injurious influence on animals descended from healthy stock. It is along our eastern coasts, on exposed highlands, that rheumatic affections chiefly occur; but they also appear wherever young lambs or delicate house-fed sheep are exposed to inclement weather, and particularly to frosts, damp, cold, or high winds. Wet and boisterous weather is more detrimental to sheep than dry cold, however intense, against which the fleecy covering of the sheep is a pretty effectual protection. Cold conjoined with wet is, however, exceedingly injurious to all animals, and the active cause of many diseases.

In acute cases of rheumatic lameness constitutional and local treatment must be united. Merely local remedies are not alone sufficient; for the appearances which we recognise as the disease are but local indications of a general ailment. To effect a radical cure we must strike boldly at the root of the evil, and not rest contented with the removal of symptoms. Constitutional treatment is especially indicated when the pulse is full and strong, with the presence of other febrile symptoms. In such cases the abstraction of blood will be of much service. It may be drawn from the jugular, from the large vein on the inside of the thigh, or from the vessels on the lower surface of the tail. The blood, drawn by a small phleme or lancet, should be allowed to flow until the quality of the pulse be amended, until it becomes softer and less resisting. Six or eight ounces are generally sufficient to effect this change. Some sedative medicine should then be given, such as four or five drops of Fleming's tincture of aconite, diluted with water, and repeated every two hours until the febrile symptoms cease. As a sedative for the lower animals aconite is incomparably the best; no other medicine quiets the pulse or

relieves fever so speedily and effectually. In rheumatic cases the bowels are generally torpid, and this state must be promptly counteracted by the administration of three or four ounces of common or Epsom salt. It is advisable to dissolve it in a liberal supply of water, and conjoin about an ounce of ginger. If the patient will lick common salt or nitre, it should be encouraged to do so, as the ingestion of such saline matters solicits the action of the bowels, skin, and kidneys, and probably also exerts a beneficial effect upon the blood. In chronic cases much advantage results from the use of calomel, opium, and turpentine, which may be mixed in the proportion of two scruples of each of the two former and one drachm of the latter. The mixture should be administered in some gruel, linseed tea, or treacle and water. The topical treatment consists in applying flannel bandages to the legs; and in chronic cases rubbing the swelled joints, distended bursæ, and contracted tendons with spirit of hartshorn, opodeldoc, oil of turpentine, or any mild stimulant. A useful combination for such purposes consists of equal parts of ammonia, oil of turpentine, and linseed oil. Moreover, especial care must be taken to prevent undue exposure to wet and cold. The patients must be placed in a carefully sheltered field, or, better still, in a paddock, where they can be brought under cover at night, and must have a good supply of easily-digested laxative food. Even under favourable circumstances the cure of rheumatism is seldom very satisfactory. The parts always remain more prone to subsequent attacks. Where the joints become extensively diseased the cure is especially troublesome and protracted, often extending over several months. As with other diseases prevention is the soundest policy. Wet lands must be dried; exposed cold pastures sheltered by belts of plantation, hedge-rows, or walls; a high standard of health maintained by regular good feeding and careful management; and stock selected free from all hereditary taint. Thus will rheumatic lamenesses be greatly diminished and deprived of their severity.

Paralysis.—Sheep are occasionally subject to paralysis or palsy, which generally interferes with the movements of the hind limbs. It consists in a deranged or imperfect action of the motor nerves supplied to these parts, and is sometimes traceable to inflammation and softening of the spinal chord and larger nerves. It occurs under the same conditions as rheumatism, and is often mistaken for it. It frequently occurs amongst young lambs exposed to extreme cold. In predisposed subjects it is apt to result from obstinate constipation or the ingestion of indigestible or novel food. It is said sometimes to attack sheep when first put upon turnips, and Mr. H. Cleeve mentions its following on two occasions the liberal use of mangold wurzel.

This is recorded in the first volume of the Journal of the Royal Agricultural Society of England. The appropriate treatment consists in removing everything that may have tended to develop the disease, making the animal as comfortable as possible, opening the bowels by smart purgatives, as six ounces of salt with a scruple of calomel or one or two croton beans; and, if there be weakness, exhibiting nutritive food and mineral tonics, such as the sulphate of iron or copper, repeated two or three times a day in doses of a drachm. In some cases of paralysis in man nux vomica or strychnia is useful, and the same remedies might also occasionally be serviceable in sheep. As they are very potent and only useful in particular cases, they must however be employed with extreme caution.

Scrofula and Rickets.—Injudicious breeding in and in, bad feeding, overcrowding, and other debilitating influences are apt to produce in any of the lower animals a peculiar degenerate state of system, known as scrofula. In all animals it is indicated by thinness of the skin, softness of the muscles, and delicacy of constitution. It is often hereditary. It frequently leads to unhealthy inflammation, accompanied by the outpouring of yellow, glutinous, tubercular matter, which, instead of being organized like healthy lymph, exhibits a great tendency to break up and soften. In scrofulous sheep such tubercular deposits are laid down in various parts of the body. In early life they occur on the membranes of the brain, causing water in the head, or in the mesenteric glands, inducing tabes mesenterica, or consumption of the belly. In more advanced life they appear chiefly in the lungs, developing all the well known symptoms of pulmonary consumption; on the mucous membrane of the alimentary canal, producing dysentery; or in the glands about the throat, giving rise to unhealthy, troublesome tumours. The scrofulous matter is sometimes found in the synovial membrane of joints, causing a soft puffy enlargement, and gradual destruction of the cartilage. Such swellings sometimes occur in newly-born lambs. The interior of some of the larger joints, usually the stifle and hock, are much inflamed, swollen, and painful, and contain accumulations of pus, which cause much constitutional irritation, and frequently prove fatal within a few days after birth. A scrofulous state of system is the parent of rickets, which is occasionally met with amongst lambs. In this disease the bones, from mal-nutrition, contain an imperfect supply of inorganic or earthy matter, and are consequently soft and yielding. Under the increasing weight of the animal, they become bent and distorted. In rickets, and indeed in all these forms of scrofulous disease, good nutritive food must be liberally supplied. Oil-cake, linseed, and such other oleaginous

articles, are of much service. A warm and comfortable pasture or loose house must be provided. A scruple of sulphate of iron with some ginger should also be given daily. As the disease often results from a hereditary, depraved state of system, care must be taken to breed only from animals of untainted constitution. But as it may also result from ordinary health-depressing causes, the general health must be maintained in a sound and vigorous state.

Black-leg.—Most animals are liable to extravasations of blood, resulting from fulness of the vessels and weakness of the coats of those vessels. Such are cases of apoplexy in man, in which the thin delicate vessels of the brain are ruptured and blood effused, causing often fatal stupor. Such are many cases of parturient apoplexy in cattle, in which the overloaded vessels in contact with the soft structures of the brain and other nervous centres give way, and the effused fluid presses upon these delicate structures, arresting motion, perverting sensation, and often destroying life. Such also are cases of black-quarter or congestive fever in young cattle, in which the vessels, over-distended with rich blood, discharge themselves into the cellular tissue about the quarters, loins, or fore-limbs. Sheep are liable to a disease closely analogous to this, and generally known as black-leg, hygham striking, or sheep-fever. Although occasionally seen in various parts of the country, it seems to prevail chiefly in the Midland counties, and usually exhibits the following symptoms. The animal is dull and feverish, the breathing and pulse are accelerated, the mucous membranes are reddened, and the bowels torpid. Dragging of the limbs with a halting gait is soon perceptible. A diffused swelling, soft and crackling from the presence of gas, soon appears about the back, loins, or quarters, or between the fore-legs—wherever, in fact, the tissues are soft and largely mixed with cellular tissue, and the bloodvessels consequently less perfectly braced up. The pulse now becomes soft and imperceptible, and death supervenes in a few hours from the excessive loss of blood. After death the mucous and serous membranes are often found coated with blood, the internal organs are bloodless, and the vessels unusually empty. The swellings contain black blood, which speedily putrefies, with evolution of gas. They show no evidences of inflammation except where life is prolonged for some days, and inflammation established from irritation caused by the extravasated blood. The disease often runs its course so rapidly that remedial measures are of little avail. If the animal is observed before extravasation occurs, blood must be freely abstracted to counteract the congested state of system. The bowels must be moved by three or four ounces of Epsom salts with a scruple of calomel. When the swellings have appeared, blood-

letting is worse than useless, for the vascular fulness will then have yielded to the natural bleeding. All that can then be done is to open the swellings, wash the parts with vinegar and water, and support the failing strength with tonics and stimulants.

The disorder consists in the elaboration of an unduly large quantity of rich blood. Hence its occurrence in highly bred, rapidly growing, and well thriving sheep. Hence its most common appearance in spring and autumn, when the grass is rich and luxuriant. Hence also the fact of its occasionally attacking sheep fed on stimulating nutritive artificial food. These facts suggest the appropriate means for warding off the malady. Whenever it appears, the flock must immediately be changed to barer or poorer pasture. Those that are well-bred, young, and in high condition must be narrowly watched, as they are apt to be the first victims, and to these it is further a safe precaution to give a dose of laxative medicine. Bloodletting and setoning, although occasionally useful, are not requisite if the animals are promptly placed on short allowance. Amongst calves the use of oilcake certainly in great measure prevents the occurrence of the disease probably by keeping the animals constantly growing, and by imparting tone to their vascular system. Its employment amongst sheep would, in all likelihood, be attended with similar benefit.

Tumours and Bursal Enlargements.—Swellings sometimes appear about the limbs of sheep, causing stiffness and lameness. They often result from blows or external violence. When of recent origin, hot and painful, they are much relieved by being fomented with hot water; and under such treatment often disappear. Sometimes, however, the exuded lymph degenerates into pus, the swelling becomes soft and fluctuating, and must be opened with a lancet or penknife. When the matter escapes the wound, if kept clean, speedily heals. In other cases the lymph is organised and the swelling becomes hard, solid, and persistent. Although unsightly and presenting mechanical interference to the movement of the joints, these enlargements are not painful, and may usually be materially reduced by smart friction with stimulant embrocations, such as camphorated spirit, turpentine, or tincture of cantharides.

Sheep as well as cattle are subject to peculiar chronic swellings, which appear in the neighbourhood of joints. They are most commonly found about the knee, are situated in the cellular tissue between the skin and capsular ligament of the joint, are intimately connected with the thickened skin, are hard and tense, capable of being moved about in any direction, quite indisposed to soften or suppurate, and unaccompanied by pain or tenderness. From their interfering mechanically with the

motions of the joint, they cause inconvenience or stiffness, but neither pain nor actual lameness. They contain a small quantity of serous fluid amongst innumerable layers of lymph, which pass in all directions, dividing the swelling into many compartments. Such tumours commonly result from the animal bruising the skin by lying down upon hard stones or rough ground. To mitigate or prevent the recurrence of such injury, nature prepares a natural pad. Serum and lymph are poured into the cellular tissue. The lymph shortly becomes organised and partitioned off into separate compartments, which are lined with a smooth secreting serous membrane. Lancing, blisters, and firing are quite ineffectual in removing such tumours, for such remedies cannot cause the reabsorption of the lymph or the destruction of the secreting serous membrane. One method of reduction consists in passing a large rough seton of plaited tow, horse hair, tape, or metallic wire through the swelling. It ought to be moved about at intervals, smeared with some acrid matter if it do not act powerfully enough, and retained until free suppuration is established. To prevent laceration of the skin, the ends of the seton ought not to be tied together, but left free, with a bit of wood attached to each. But this method of treatment, although it materially reduces the bulk of the tumour, does not always entirely or permanently remove it. The secreting membrane usually remains, and pours out fresh organisable materials, and a second tumour is gradually produced. Reproduction of the tumour may, however, be effectually prevented by removing the whole of its contents. A free incision must be made upon its lower surface. Every portion of lymph, every shred of membrane must be pressed or torn out. Inflammation is of course the result of this violence, and is of great utility in contracting the skin, and promoting its adhesion to the capsular ligament of the joint, thus obliterating the cavity occupied by the growth. To keep the inflammation within manageable limits, and prevent the excessive outpouring of serum and lymph, the limb must be swathed in a thin light bandage, which ought to be adjusted so as to exercise equable pressure. To favour the exit of matter it must also be looser below than above, and to moderate the inflammation it should be wetted at intervals with cold water or diluted vinegar. The dependent orifice is not to be covered up, but, on the contrary, must be kept open with pledgets of tow until adhesion has taken place between the skin and the capsular ligament of the joint. This operation, although apparently somewhat formidable, is seldom attended with any bad consequences, and is the only certain and effectual way of removing such tumours. The same treatment, it may be mentioned, is also serviceable in the removal of similar tumours amongst cattle.

The chronic indurations described must be distinguished from swellings of bursæ, which result from over-exertion or strain of the ligaments or tendons with which the bursæ are connected. These are sometimes seen about the hock or knee, are elastic, yet tense and firm, have distinct circumscribed margins, and, unlike tumours in the cellular tissue, cannot be moved about. They are not incorporated with the skin, which is separated from them by cellular tissue, and quite free from thickening. They contain synovia, a glairy albuminous fluid, admirably adapted for the important office of lubricating tendons and ligaments, and enabling the locomotive machinery to act with the least possible friction. This oily fluid is secreted by the vascular lining membrane of these cavities, and is poured out in large quantity wherever the parts are exposed to undue action, or are subjected to injury or strain. These swellings cannot be treated in the same manner as those above described. They cannot be laid open without producing much inflammation. While hot and painful they should be enveloped in cloths constantly wetted with ice-cold water. When they become hard, tense, and painless they should be stimulated with a mustard embrocation, with spirit of turpentine, or tincture of cantharides. In inveterate cases the firing iron may be used, as it is in similar cases amongst horses. Strains of all kinds require very similar treatment, namely, cold water at first to abate the inflammation, and subsequently stimulants to accelerate the absorption of the effused products.

Diseases of the feet.—In the sheep disease of the feet, whatever its nature, symptoms, or causes, has been long recognised under the vague generic title of "foot-rot." Yet without technical nicety or undue subdivision, we discover, under that general term, several distinct diseases. They have usually a separate and independent existence; they differ from each other in nature; they affect different parts of the foot. They may be described as follows:—

Simple laceration and cracking of the horn.

Chronic ulcerative inflammation of the sensitive laminæ, to which alone the term foot-rot should properly be restricted.

Rheumatic inflammation of the feet and digital joints, analogous to the bustian foul of cattle, and distinctively styled rheumatic foot-rot.

Inflammation of the interdigital skin and adjacent sebaceous glands, sometimes termed "scalding."

Specific inflammation of the interdigital skin, prevailing as an epizootic, affecting all cloven-footed animals, accompanied by the formation of vesicles between the hoofs, in the mouth, and

wherever the skin is thin and fine, and generally known as murrain, or the vesicular epizootic.

Laceration or cracking of the horn.—From irregular or excessive growth, the horn is liable to become torn, thus producing temporary lameness. If, however, the animal be early observed, and the lacerated parts removed by a sharp knife, the foot reduced to a proper shape, and the injured part, if necessary, bound up, no serious consequences will ensue. But such simple mechanical lesions, when neglected, frequently lead to foot-rot in the manner to be afterwards described. In dry weather, and especially on light sandy soils, the hoofs sometimes crack much in the same way as in horses. This, although but a trifling matter, is apt when neglected to lead to inflammation of the vascular parts beneath, with sprouting of proud flesh. The hoof must be well oiled, softened if possible by a poultice, and the gaping edges of the horn brought together and secured by a tarred thread. A boot or piece of tarred cloth should be used as a protective against the access of filth.

Foot-rot.—Foot-rot has probably existed from the earliest times. In this country, however, it has become greatly more general during the past century. Mr. W. Hogg, writing in 1832, says it is little more than twenty years since the disease affected the Cheviot flocks of Scotland.* Mr. Laidlaw of Bower Hope, writing at the same time, states that it first appeared amongst the Highland blackfaced sheep only thirty years before.† This increased prevalence of the disease is probably ascribable to the greater weight of all varieties of sheep, and also more especially to their occupying soft, moist, lowland pasture previously unreclaimed or grazed only by cattle.

The symptoms of foot-rot are eminently characteristic. The horn becomes overgrown, soft, and disposed to crack or tear. Sand and dirt insinuate themselves into its pores or cracks, the overgrown horn turns inwards upon the sole, or the outer insensible covering of the sole is otherwise worn down. Irritation and inflammation of the sensitive laminæ of the sole and walls are thus produced, accompanied by the discharge of thin fœtid pus. The foot is swollen, hot, and tender, and the pastern arteries pulsate strongly. Lameness is early observable; the pain of walking is frequently so great that the patient goes upon its knees, and usually becomes much reduced in condition. All the feet may be affected, but the disease is often confined to the fore feet, sometimes to only one of them, and occasionally even

* 'Quarterly Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland,' vol. iii. p. 308.

† Ibid., p. 314.

to one digit. Such are the ordinary symptoms of a case of foot-rot; but they are liable to many complications and aggravations. Frequently the inflammation involves the mucous glands within and about the biflex canal, giving rise to an acrid, noisome discharge, and a chronic, unhealthy, painful ulceration. The horn, being little exposed to wear, generally becomes overgrown and much distorted. Sometimes the coronary substance and sensitive laminæ are so acutely inflamed that copious exudations are poured out, tearing asunder the horny and sensitive laminæ, and occasionally, in neglected or badly-treated cases, discharging themselves by unhealthy, sinuous openings around the coronet. Sometimes these sinuses run inwards, laying bare the coffin-bone, and inducing disease of the periosteum—serious complications, which are most frequent in heavy-bodied sheep kept in wet, cold situations. When the crust has shelled off, granulations, usually known as proud flesh, sprout up. On the sole and heel surfaces these granulations become tough, stringy, and intractable, much like those thrown out in canker in the foot of the horse. During summer weather the accumulations of matter and the raw surfaces invite the attacks of flies; and the wounds soon swarm with maggots, which materially aggravate the malady.

Foot-root almost always leaves the parts weak and prone to subsequent attacks. Sheep that have once suffered from the disease are apt to become affected during hot dry weather, hard frost, or from other causes that would be inadequate to produce it amongst perfectly sound stock. The same foot or digit frequently suffers at short intervals. The hoofs of those subject to the malady become large and soft, and this altered and weakened structure is transmitted to the progeny. Indeed it is a common observation that a certain hereditary appearance of the foot predisposes to foot-rot.

It may be interesting briefly to advert to some of the opinions propounded, regarding the nature of foot-rot. Sir Antony Fitzherbert in his 'Book of Husbandry,' written in 1523, ascribed it to the presence of a worm in the foot. He says, "There be some shepe that hath a worme in his foote that maketh hym halte. Take that shepe and loke betweene his clese, and there is a lyttell hole, as moche as a grette pynnes heed, and therein groweth fyve or syxe black heares, like an inch long and more." —(p. 40.) He proceeds to give most explicit directions for excising the biflex canal, which he describes as "a worme lyke a piece of fleshe, nyght as moche as a lyttel fynger: and when it is out put a lyttel towe into the hole, and it will be shortly hole." This absurd notion respecting the nature of the disease has not yet been quite exploded. The disease is sometimes

ascribed to flies depositing their larvæ about the interdigital space, and the maggots, which in hot weather infest many cases of foot-rot, are referred to in support of this view. But these maggots are an accidental consequence of the disease, and not the cause of it. Others have thought that foot-rot was produced by minute parasitic animalcula, which were developed on certain pastures, attached themselves to the feet of the sheep, and induced irritation and inflammation. But there is no proof of the existence of any such creatures. Mr. Spooner in his 'History, Diseases, &c., of Sheep,' says, "it consists of inflammation and suppuration, and often ulceration, of the sensible and secreting parts of the foot, and results from contact with vegetable bodies in a state of putrefaction." The definition of the disease is good; the explanation of its production is very insufficient. No doubt if sheep stand much upon decaying vegetable matter their feet become soft and liable to the disease, in the same way as if kept upon any soft moist pasture. But the decaying vegetable matter is only one of the many causes of foot-rot, and by no means one of the most common.

Foot-rot is liable to be produced in many different ways, and by the most dissimilar causes. It often results from the overgrowth of the hoof, and the turning in of the toe, pressing upon and irritating the sensitive laminæ. This is especially apt to occur amongst sheep brought from indifferent upland pastures to rich meadow lands. Hence the notorious prevalence of the disease amongst black-faced, Cheviot, and South-down sheep, carried from their native walks into rich arable districts. On their native grazings the surface of the soil is usually rough and rugged, whilst the grass is not over-abundant, and the sheep have therefore to stray considerable distances before they can procure a sufficiency. Under such circumstances, the production and waste of the horn are fairly balanced. When, however, such sheep are transferred to smooth, well rolled, rich lands, or to soft, moist, luxuriant meadows, the abundance of food removes the necessity of much walking, the tear and wear of the hoof is accordingly reduced, the horn shoots out in exuberant quantity, and usually also of less compact structure, while the sole also usually becomes convex, causing much pain, and the production of troublesome ulcers. The crust hence becomes liable to laceration, and the sensitive parts of the foot are thus exposed to mechanical irritation, as well as to the injurious influence of extreme cold, heat, and moisture. Again, the overgrowth of horn and consequent lengthening out of the toe, injures the foot in another way. It exposes the sensitive laminæ to unwonted strain, and thus renders them weak and unfit for the secretion of healthy horn. A softened, spongy, and degenerate

crust is accordingly produced, which, like that resulting from the constant exposure of the foot to moisture, forms an inadequate protection for the sensitive parts, and permits the insinuation of foreign bodies through its open pores. These views were first enunciated by Professor Dick of the Edinburgh Veterinary College, in an able and interesting paper, published twenty years ago, and afford a most rational and satisfactory explanation of the production of the majority of cases of foot-rot.* We can now readily understand why the disease prevails so generally on rich flat meadows, lawns, mosses, low-lying pastures, as well as on soft marshy grounds and in wet seasons.

Foot-rot occasionally appears amongst sheep upon loose sandy soils, depending, as in the cases above referred to, on the excessive and faulty growth of horn, and the consequent access of foreign matters, which excite inflammation of the laminæ. The soft and yielding nature of the soil does not cause the due wearing away of the crust, or the extreme dryness favours its cracking and splitting, while the fine silicious particles readily insinuate themselves into any holes or fissures. From somewhat similar causes, the disorder also occurs during the dry months of summer, and upon well-drained lands. In such cases it may usually

* The following extract from Professor Dick's well-known paper affords a clear and simple account of the operation of some of the more prominent causes of foot-rot:—"The finest and richest old pastures," says the Professor, "are particularly liable to this disease; soft, marshy, and luxuriant meadows are equally so; and it is also found in light, soft, or sandy districts. In the first of these it is perhaps most prevalent in a moist season, and in the latter in a dry one: in short it exists to a greater or less extent in every situation which has a tendency to increase the growth of the hoofs without wearing them away, and more especially where they are kept soft by moisture. It is so prevalent in fine lawns and pleasure-grounds, that they are in many instances reduced in value to a mere trifle as a pasture for sheep; they are said to be *infected* with this disease, and having once become so, the vicissitudes of *seven* seasons are scarcely sufficient to destroy the contagion. A luxuriant herbage on soft pastures is equally subject to it, and in both cases the disease is increased in a wet season. The reason why in these situations sheep are so liable to the disease is obvious; they are generally brought from lands where their range of pasturage was greater than in these situations. In their former state, from the exercise which the animal took and the nature of the ground on which it pastured, the hoof was worn down as it grew. But under the state in question, the hoofs not only continue to grow, but where the land is moist that growth is greatly increased, and the animal does not tread upon hard ground, nor has it exercise to wear them down. Now, in the case of man himself, when the nails of his fingers or toes exceed their proper length, they break or give him such uneasiness as to induce him to pare them; and the same takes place with the hoof of sheep. But there is this difference in the case of the latter, that when their hoof once breaks, as the animal has not the power of paring it, the part thus broken must continue a wound. Some parts grow out of their natural and proper proportions; the crust of the hoof grows too long, and the overgrown parts either break off in irregular rents and unnatural forms, or by over-shooting the sole allow small particles of sand or earth to enter into the pores of the hoof. These particles reach the quick and set up an inflammation, which is followed by the destructive effects which are too well known to require description."—*Quarterly Journal of Agriculture,* vol. ii. pp. 855–6.

be traced to cracks in the dry horn, similar to those occurring in sandcrack in the horse, or to undue wearing away of the horny sole, from friction with the hard dry soil. Such cases are generally accompanied by much inflammation of the interdigital sebaceous glands.

Foot-rot does not invariably depend upon an overgrowth of horn. On the contrary, it sometimes results from the horn being unduly worn, thus exposing the quick to filth and moisture. This is of common occurrence amongst sheep that have been driven long distances upon hard roads. Their feet are bare, battered, and painful, and if previously overgrown they are now cracked and torn, affording ready lodgment for dust or other foreign bodies.

And now we approach the much-debated subject of contagion. Most shepherds, as well as the majority of sheep-masters, and many veterinarians believe the disease to be decidedly contagious. They consider that animals will take the disorder by travelling over a road previously traversed by unsound stock, or by being penned in yards previously occupied by such stock. They believe that the contagion will sometimes lurk in a pasture and affect sound sheep placed upon it, even after long intervals of time. They record cases of rams communicating the disease to whole flocks of ewes. They enjoin many precautions for keeping the sound and unsound stock separate. They highly approve of the judgments given by various courts of law, both in this and other countries, in which the contagion of the disease has been admitted, and damages awarded for loss and injury sustained by the introduction of unsound sheep amongst a previously healthy flock. But these conclusions are, we believe, erroneous. They are established on insufficient data, and on imperfect and partial observations.

The common foot-rot, above described, is, I believe, not contagious. It does not exhibit the characters of a truly contagious disorder, and its occurrence and spread can be simply and rationally explained without referring it to contagion.

The very decided opinions commonly entertained regarding the contagiousness of foot-rot have in part resulted from its being frequently mistaken for the contagious murrain, which much resembles it. This opinion is strengthened by the statements occasionally made of the disease being communicated to cattle, pigs, and poultry. Gasparin, in his ‘Manuel de l'Art Vétérinaire,’ says “it occasionally spreads to the pigs, dogs (?), and even the poultry,” and I have heard various sheep-masters express a similar opinion. But such phenomena, although observable in murrain, which affects all the cloven-footed domesticated animals, does not apply to true foot-rot. The rapid spread

of this disease, and its general prevalence amongst a stock, although an apparent argument in favour of contagion, depend, I believe, merely upon the animals being equally exposed to the same morbific causes. These phenomena certainly indicate the operation of some common, and, it may be, wide-spread cause of disease, but cannot, without much corroborative evidence, be accepted as adequate proof of contagion.

Again—the production of foot-rot by inoculation is recorded as an unanswerable argument in favour of its contagion. M. Gohier and others have applied the matter of foot-rot to "sound" (?) feet, and thereby succeeded in producing the disease. But the most favourable experiments were by no means uniformly successful. Indeed, in M. Gohier's cases only two out of six took effect; and in M. Favre's only twenty out of thirty-two.* Further, it is to be specially remarked, that the matter is quite innocuous when applied to the sound horn, and only acts when directly applied to the sensitive laminæ. Those who endeavour to prove the contagion of the disease by such facts must therefore admit that the matter of foot-rot is without effect when applied to the sound foot, and acts only when the quick has been laid bare. But this unavoidable admission is almost fatal to the argument; for it shows that inoculation is only successful when practised in cases which must be certainly regarded as already in the incipient stage of the disease. In brief, the question stands thus:—A foot with a torn or abraded surface, for this is a *sine quâ non*, comes in contact with the matter of foot-rot; and then, say the contagionists, the disease is set up, foot-rot is established. But lesion of the horn, the first stage of the disease, has already occurred before the possible intervention of this contagion, and the subsequent stages will certainly follow provided the sensitive and irritable parts be exposed to cold, filth, or moisture. To these almost ubiquitous agencies we ascribe the onward progress of the case. It must, however, be admitted that the matter of foot-rot, when rubbed into the vascular parts of the foot, is *capable* of acting in a similar manner. But the practical question arises: Is the matter of foot-rot the active cause which in ordinary cases produces the ulceration and suppuration of the later stages of the complaint? I think not, and for the following reasons: 1st. The quantity of matter even from a bad case of foot-rot is small, often not exceeding a drop or two in several hours; and experiments show that even when recently collected and freely used it is not very active, and fails in many cases to produce any effect whatever. 2nd. Sheep with foot-rot are certainly little apt to move about, and

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* Youatt on Sheep, p. 530 and 533.

generally remain apart from their fellows; and yet it is pretended that a few sheep will infect a pasture of several hundred acres in extent. 3rd. Even although a whole pasture were saturated with the dreaded matter, little harm would ensue. The sound hoofs could not suffer in the slightest degree, while the injured or battered ones, so long, at all events, as only one foot is affected, are rarely put to the ground, and hence are little liable to come in contact with the inoculable matter. 4th. The disorder is developed as readily by the foul matter of thrush, canker, grease, or any unhealthy wound, as by the matter of foot-rot, showing that the supposed contagious matter has no special potency, and that the disease has nothing of a peculiar or specific character.

In further evidence of the non-contagious character of the disease, it may be remarked, that one foot or even one digit is frequently affected without the other feet or digit becoming involved; that sheep with foot-rot may be mixed with perfect impunity amongst a sound flock, provided they be upon good dry pasture and have their feet properly attended to; that the disease is only produced under conditions which in themselves and apart from contagion are adequate to produce the inflammation of the laminated structures in which foot-rot consists; and lastly, that the removal of an affected flock to dry, barish good pasture, the occasional paring of superfluous horn, and the avoidance of causes which induce irritation, most certainly arrest the spread of foot-rot, but could have little influence in staying the progress of a truly infectious disease.

Whenever the first symptoms of lameness are observable, the sheep must be caught, and the feet examined. All filth and dirt must be removed, as well as every loose, ragged, and unsound portion of horn. This is generally effected with a stout pocket-knife, but, when the horn is extensively diseased, a fine-pointed drawing-knife is often useful in removing, as must be scrupulously done, all portions of horn separated from the laminæ. The subsequent application of tar is of much value in protecting the bared surface from filth and moisture. When the inter-digital skin becomes involved it may be dusted daily with powdered sulphate of zinc or copper, or gently touched with a stick of nitrate of silver. Ulcers in the digital space, on the sole or elsewhere, should be touched with nitrate of silver, a drop of nitric acid, or a little of the old butter of antimony. Where they are tedious or unhealthy, a poultice is often useful, and a round of different astringent or caustic applications must be tried until decided amendment supervenes. Frequent changes of the remedies are often of more service than the continuous use of any one, however good. The fungous growths, which are often

so troublesome in bad cases of foot-rot, are best kept down by nitric acid, sulphate of copper, or the gentle application of the red-hot iron, together with constant pressure, which may be applied by rolling the foot tightly up in a linen rag, secured as ingenuity may best suggest. In deeply penetrating sinuses, the carious bone, sloughing cartilage, or other cause of irritation upon which such wounds depend, must be promptly removed, a dependent orifice secured, astringents injected, and every means adopted to preserve cleanliness. The injection of strong caustics, a very common but painful mode of treatment, must only be adopted when other remedies have been tried and failed. To ward off the attacks of flies, which during warm weather are very annoying, the parts should be freely smeared with coal-tar, spirits of tar, or naphtha. In all cases of foot-rot, no matter how slight, the appropriate treatment must be promptly and diligently prosecuted, otherwise the case is very apt to pass from bad to worse. The examination of the feet and the suitable dressings should, except in the mildest cases, be performed daily. After the removal of horn or the use of caustics, it is important that the animals should stand for a few hours upon dry sawdust or straw, or be driven for a few minutes amongst several inches of quick-lime.

The observations already made regarding the causes of the disease will sufficiently indicate the appropriate means of prevention. The growth of the horn must be kept within moderate limits. Sheep on soft moist lands should have their feet examined every few weeks, and any redundancy of horn removed. They may be driven occasionally along a hard road, which will accelerate the defective wear. Severe overdriving must be avoided, as well as all other causes which induce congestion of the laminæ and injury of their invisible covering. Draining very frequently puts a stop to the ravages of foot-rot; for, by drying the land, it prevents the injurious influence of moisture and cold, and leads, moreover, to the growth of a firmer and better turf. Liming must also be regarded as a preventive. Like draining, it ameliorates the pasture, and removes especially that soft mossy herbage which is so prone to develop foot-rot.

Rheumatic Foot-rot.—This disease, known as bustian-foul or joint-foul, is sometimes improperly styled founder, and is distinguished from foot-rot by several important characters. It is a constitutional malady, while the other is purely local. It is a chronic, unhealthy inflammation, affecting the soft structures about the fetlock; whilst the other in its ordinary form is simple inflammation of the foot alone. It seldom attacks more than one foot at a time, while the other frequently affects two, and sometimes all the four. It progresses slowly, is accompanied by typhoid

fever, shows a marked tendency to involve the structures of the joints, and is most difficult of cure ; while the other, when early attended to, is of short duration, often unaccompanied by febrile symptoms, and usually easily curable.

The symptoms come on gradually. Lameness is observable, the limb is projected, and the parts about the fetlock are hot and tender. After some days a diffuse swelling appears about the coronet, making the feet look smaller than natural. In a word, there is inflammation of the skin, coronary substance, tendinous sheaths, and synovial bursæ. Fever is present, digestion is impaired, and in the suckling ewe the secretion of milk is arrested. This state of matters may continue for a week or ten days, or even longer, the irritation augmenting, the fever assuming a more typhoid type, and the emaciation increasing. Suppuration is slowly established, but the matter gradually comes to the surface, and must be freely evacuated. From the inflammation involving the laminated structures, sloughing of the hoofs is apt to occur. In aggravated cases the inflammation eats its way through the capsular ligaments of the joints, and the cartilage and bone become diseased. In such cases the swelling and general irritation are much increased, sloughing of the ligaments and caries of the bones supervene, giving rise to a most fœtid acrid discharge, which usually evacuates itself through several narrow openings with angry-looking ulcerated margins. If the probe or finger be introduced, the carious state of the bone is easily discovered by its roughened, grating, bleeding surface. In such cases the animal is so wasted and debilitated, that a cure is almost impossible, and can only follow where the joints become anchylosed or fixed by the deposition of bony matter around them.

The disease occurs amongst cattle as well as sheep. It especially affects animals of an unhealthy constitution, such as those that are scrofulous or rheumatic. It exhibits, indeed, many of the characters of rheumatism. Thus it affects structures of a comparatively low organisation, goes on tardily to the formation of pus, and occurs chiefly amongst stock in cold, exposed situations, and amongst which other forms of rheumatism prevail. It does not, however, like acute rheumatism, show much tendency to shift about. It occurs in adult rather than young sheep, and prevails often amongst those that are house-fed and in gross condition.

The treatment of rheumatic foot-rot requires much time and patience and a good deal of discrimination, for the several phases of the malady demand the employment of different remedies. It will, in the first place, be convenient to remove the patient to a house, shed, or paddock, near his attendant. In

the earlier stages poultices are requisite. From the low organisation of the inflamed parts, and the chronic nature of the complaint, they are best used cold. Indeed, cold applications are preferable to hot in most injuries and diseases of the limbs of cattle and sheep. Hot applications, while they soften and soothe, dilate the vessels, favour the determination of blood, the progress of effusion, and the formation of pus. Cold applications, on the other hand, contract the dilated, inflamed vessels, and impart tone, thus diminishing the afflux of blood and the tendency to effusion. They are conveniently applied in the form of poultices of cold mashed turnips, linseed meal, or carrots, which must be kept soft, moist, and cool, by frequent effusion of salt and water, diluted vinegar, or butter-milk. The hoof must be carefully thinned down, and all sources of irritation removed. General bloodletting is rarely necessary, but local bloodletting is often of advantage in reducing the swelling and pain. A small phleme or lancet is plunged into the vascular plexus above the heels, or the toe is pared until blood springs, while the flow may be encouraged by placing the foot in tepid water, and is easily stopped by some wet tow and a bandage. Saline laxatives should be given if the bowels are torpid. Febrifuges, as recommended in rheumatism, are also sometimes required. The food should be soft, laxative, and easy of digestion. Where the treatment recommended is pursued for some days without benefit, matter must be forming in the deep-seated parts, and all endeavours to put back the inflammation will be fruitless. The end to be now sought is the speedy maturation of the abscesses, and this may be expedited by hot fomentations and poultices, and supporting the animal's strength by good nutritive food. Whenever the matter reaches the surface, incisions with free dependent orifices must be made for its speedy evacuation. Astringents and even caustics are now of advantage. Solutions, containing from ten to fifteen grains of sulphate of copper or corrosive sublimate to the ounce of water, should be injected at intervals ; or this may be varied by the substitution of diluted nitric acid, in the proportion of twenty drops to the ounce of water, or by Burnett's solution of chloride of zinc. These last two are especially suitable where there is a strong fœtid odour, when bleaching-powder and charcoal are also useful. Butter of antimony, undiluted acids, and solid caustics, are usually inadmissible, except for keeping down surface granulations. They cannot with propriety be injected into the wounds, as they cause great pain, lead to sloughing, and uselessly retard the progress of the cure. The outer wounds must be kept scrupulously clean, and dressed with mild digestive ointment.

Interdigital Inflammation.—In dry, hot summer weather, heavy,

well-conditioned, plethoric sheep are liable to suffer from a variety of so-called foot-rot, manifesting somewhat different symptoms from those described. The skin occupying the interdigital space becomes hot, tender, and thickened. In the language of the shepherd, the parts are "scalded." The mucous glands between the digits, in the biflex canal, and in the hollow of the pastern, participate in the inflammation. At first they cease to yield their lubricating secretion, and subsequently pour it out of a vitiated quality, at first thin and serous, and shortly thick, adhesive, and often acrid. Flies, especially during hot weather, are attracted to the thick, sticky discharge, and materially aggravate the irritation. Meanwhile lameness increases, the animal is unable to follow its companions, sometimes reduced to the extremity of going upon its knees, and falls back in condition. The fore feet, from their supporting more weight, are usually worse than the hind. All the feet are sometimes affected, rendering the animal very helpless. Febrile symptoms occasionally supervene. The inflammation may extend to the coronary substance, causing heat and tenderness round the top of the hoof, and interfering with the secretion of horn, which becomes soft and brittle; and sometimes, from the alternate arrestment and re-establishment of the secretion, assumes a ridged, irregular appearance. The foot is not freely used, and the horn at the toe becomes excessive, ragged, and split. Sand insinuates itself into the cracks, aggravating the lameness, and thus the symptoms of common foot-rot are frequently superadded to those just described. Occasionally also the soft parts above the foot become involved, the skin ulcerates, abscesses appear, with the symptoms of rheumatic foot-rot. Such complications usually occur in animals of a delicate, rheumatic, or scrofulous race.

The milder forms of this complaint, consisting of simple inflammation of the skin and mucous glands about the interdigital space, are exceedingly common, and often exist without any inflammation of the laminæ, deterioration of the horn, or other symptoms of ordinary foot-rot. Anything irritating the delicate structures between the digits will produce it. Amongst the most common causes are: hot dry weather, diminishing the secretion of the lubricating fluid; continued exposure to cold and wet, inducing relaxation and depression, with subsequent reaction and consequent inflammation; long travelling upon hard roads, exhausting the oily secretion and exposing the parts to unwonted friction; the lodgment of dust and filth, or the walking amongst long hard grass, causing direct irritation. This scalding also occasionally occurs from constitutional causes. Thus it sometimes accompanies derangements of the digestive organs, in which all parts of the skin, from their resemblance to the alimentary mucous

membrane, keenly sympathise. From this cause it seems frequently to occur in young lambs in connection with indigestion. It frequently presents itself among tups towards the end of summer, and from their irritable state of system is then most difficult of cure.

In the treatment of these cases of interdigital inflammation, the parts must be carefully cleaned with soap and water of all adhering filth and all noisome glutinous discharge. When the skin is merely red and tender without throbbing or swelling around the coronet, an astringent dressing should be immediately applied: the sort of astringent is a matter of secondary importance. From eight to ten grains of acetate of lead (sugar of lead), sulphate of copper (blue vitriol), or corrosive sublimate, dissolved in an ounce of water, will do excellently well, and two or three applications will usually effect a cure. A drop or two of spirit of tar is likewise a good remedy, as it both stimulates to a more healthy action and prevents in great measure the attacks of flies. Driving the animals amongst hot lime, as in ordinary foot-rot, is also much recommended. In obstinate cases I know of nothing better than the solid nitrate of silver (lunar caustic). One of the little sticks inserted in a goose-quill to prevent wasting and blackening of the fingers, should be passed firmly and regularly over the whole of the raw surface. To defend the foot from moisture or dirt, it is usually advisable to envelope it in a tarred cloth, or give it a protecting covering of tar. To prevent the occurrence of foot-rot and conduce to the animal's comfort, all loose portions of horn should be removed, and the hoof pared down if necessary. To mitigate the pain and swelling which occur when the coronary substance and soft parts above the foot become inflamed, poultices may be applied; and much relief is also obtained from the abstraction of blood, which may be readily drawn by paring down the toe. To arrest ulcerations and repress fungous growths, the same remedies may be made use of as have been above recommended in similar conditions occurring in common foot-rot. To secure the healthy action of the bowels and allay febrile symptoms, three or four ounces of Epsom salt should be given, and the animal encouraged to lick common salt. Hurtrel, D'Arboral, and other authors, regarding the disease as a destructive inflammation of the biflex canal, recommend its removal, and give detailed directions for its excision. But this operation leaves matters worse than before, exposes a greater extent of raw surface, and ruthlessly removes a useful appendage. Occasionally when the orifice of the canal is closed up by inflammation, and the accumulated contents cause painful distension, it is advantageous to dilate the orifice by a probe, or, if necessary, to make an opening with a lancet or pair of sharp scissors, wash out the sebaceous contents, and inject some mild astringent solution.

Murrain.—Foot-rot sometimes assumes an epizootic character, or, in other words, it spreads over a large extent of country, attacking at the same time many animals, and exhibiting the same general symptoms. This epizootic foot-rot is somewhat different from the ordinary forms of the disease, and is known under the name of murrain, or the vesicular epizootic. It does not confine its attacks to sheep alone, but affects cattle, pigs, goats, and other cloven-footed animals. It has not been long known in this country, having been first noticed so recently as 1839. On its first introduction it often assumed a serious form, and sometimes proved fatal; but of late years its prevalence and severity have much abated. Such phenomena are frequently observed in connection with epizootic and epidemic diseases—their virulence, at first formidable, gradually becomes exhausted, and their prevalence circumscribed. If a sheep, becoming lame from epizootic foot-rot or murrain, be caught, and the interdigital space examined, the skin is found dry and thickened and covered with little red elevations. Within a few hours the skin is raised into blisters, vesicles, or aphthæ, which sometimes extend round the coronet. At first about the size of a millet seed, they gradually enlarge and occupy six or eight times their original surface: they have undulating irregular margins. They contain at first a clear serous fluid, which gradually becomes opaque from the presence of lymph. In favourable cases the contents dry up or the vesicles burst, and a thin dry eschar or scab is formed. In many cases similar vesicles appear in the mouth, interfere with mastication, and cause a constant drivelling of saliva. When the disease affects sheep on turnips, it sometimes prevents their eating for several days, and thus checks their growth. Vesicles about the mouth are seldom, however, so numerous or troublesome among sheep as among cattle. A similar eruption also occasionally appears on the thin skin between the legs, and more particularly on the udder and teats, where the vesicles are frequently large and numerous. I have sometimes seen much inconvenience thus produced among pregnant and nursing ewes. The inflammation of the skin and mucous surfaces of the udder is apt to be increased by the sucking of the lamb, and sometimes involves the parenchyma of the organ, leading to the formation of pus, and occasioning the destruction of a large portion of the gland. Accompanying the eruption of these vesicles there is fever, usually exceedingly slight, but sometimes obtruding itself on notice by a hot mouth, an accelerated pulse, quicker and difficult breathing, with impaired appetite and retarded digestion. The febrile symptoms generally diminish as soon as the vesicles are fully formed. Throughout the complaint, lameness is of course observable, with tenderness and swelling around the coronet.

Indeed in the milder, which are also fortunately the commoner cases, lameness from the interdigital vesicles is often the only symptom which can be detected, and recovery supervenes in six or eight days. In the more serious cases the vesicles burst, and a raw surface is exposed. From the application of dirt, or from an unhealthy state of system, ulcers eat into the exposed surface, giving rise to an unhealthy noisome discharge. These untoward results most commonly occur among heavy sheep, or those that have been driven long distances, or have either been neglected or subjected to bad treatment.

The symptoms of this variety of foot-rot, when attentively considered, clearly indicate the nature of the disease. It is a specific or peculiar inflammation of the mucous membranes and skin, accompanied by the eruption of vesicles, which in sheep commonly present themselves in the interdigital space. It belongs to the exanthemata, or eruptive fevers, and hence exhibits many characters in common with measles, scarlatina, small-pox, and other diseases of that class. Like them it is ushered in by fever, is attended by eruption, seldom occurs more than once in a life-time, is contagious, and runs a definite course with which medical treatment cannot safely interfere. These, be it observed, are points which distinguish it from ordinary foot-rot and entitle it to be classed as a distinct and separate disease.

Contagion is undoubtedly the most common and active cause of murrain. Sheep are frequently attacked from travelling along a road over which an infected stock has recently passed, or from being pastured where such a flock had previously grazed. They will take it from cattle, and even from pigs, as well as from animals of their own kind. Again, in further evidence of its contagious character, it spreads slowly and gradually, often following the route of travelling droves. It appears frequently after fairs, and on the introduction of recent purchases, which are themselves the first victims. It rarely affects a few individuals, without running through the whole flock, and those which happen to be brought into closest proximity with the unsound animals first show symptoms of the malady. It is frequently communicated by the mother to her lamb, which by sucking the affected teats becomes much inconvenienced by the vesicles in its mouth. It has even been noticed with all its symptoms prominently developed in the newly-dropped lamb—a proof alike of its contagiousness and its constitutional nature. Although chiefly indicated by local symptoms, it is, to use a common phrase, a "blood disease." Unlike non-contagious maladies, it affects sheep of all kinds and under all varieties of management. It equally prevails on hill and meadow lands, in wet and dry pastures, amongst young and old sheep.

In the treatment of murrain the principle of non-intervention must be carefully recognised. Palliative measures only are justifiable. All endeavours to arrest the disease, or repress the eruption, are injurious. The eruption is in fact a natural curative process, which cannot with impunity be meddled with. Hence astringent or caustic dressings, often useful in common foot-rot, are here not only useless, but absolutely hurtful, at all events throughout the earlier stages of the disorder. Time, the cleansing of the feet from all filth, removing the superfluous or irritating horn, and placing the animals on good dry pasture, are in most cases all that is required for the maturation of the vesicles. The pain, when excessive, may be relieved by fomenting the parts, applying a poultice, or by withdrawing a few ounces of blood from the vessels around the coronet, or those underneath the sole. When the vesicles dry up or burst, a dressing of simple oil, Glauber's extract, solution of acetate of zinc, or any other mild astringent will expedite the cure. When ulcers unfortunately supervene, they will require the same treatment as ordinary foot-rot. When the mouth and lips are covered with vesicles, or painful and abraded, soft food, such as bran mashes, steamed grain, ground oil-cake, or chopped fodder must be provided. When the udder and teats are tender, they should be bathed with warm water, especially before and after the lamb is permitted to suck. They may also be washed with vinegar and water, dressed with lard or butter, and subsequently with mild astringent lotions; but these last are only permissible after the eruption has passed away. Any febrile symptoms that may arise usually yield readily to the use of some saline aperient, as three or four ounces of Epsom, Glauber's, or common salt given dissolved in water. On account of the irritable state of the alimentary canal, powerful purgatives are apt to prove injurious; but a lax state of the bowels should be maintained by giving the animal succulent green food, or mashes well sweetened with treacle. Bloodletting is rarely, if ever, called for. Loss of condition, and debility, must be prevented by supplying the patients with good, easily masticated, and nutritious food; and this is especially necessary when the mouth participates seriously in the disorder. In protracted cases, bitters and tonics are also advantageous. Two drachms each of gentian and ginger, with one or two scruples of sulphate of iron, may be added to a mash with a liberal allowance of treacle. This may be repeated once or twice a day, and will generally be freely eaten.

In the prevention of murrain, the contagious nature of the disease will indicate the necessity of strict separation of the sound from the unsound stock. Care should be taken to examine all newly purchased flocks, and to isolate all that exhibit

lameness. An interval of some weeks, with a few rainy days, should if possible be allowed to pass, before healthy sheep are placed upon the pastures previously occupied by those suffering from murrain. If the animals have been kept within doors, disinfectants must be had recourse to. Of these, the most common is chloride of lime, or bleaching powder, which should be freely strewed over the floors and applied in strong solution to the walls and woodwork. Sulphurous acid is also a valuable disinfectant. It is best produced by burning sulphur on some red-hot coals, allowing the fumes to penetrate to all parts of the building. In conjunction with these disinfectants, thorough ventilation must not be neglected, all litter must be removed, the walls whitewashed, and the woodwork scrubbed. It is generally believed that sheep once attacked by the vesicular epizootic are not again subject to its attack. Second attacks are at all events rare. This, according to Liebig's ingenious hypothesis, results from the disorder removing from the blood that peculiar morbific matter, which is believed to be essential to the reproduction of the virus and the development of the disease.

XXI.—*On some Points connected with Agricultural Chemistry.*

By J. B. Lawes, F.R.S., F.C.S., Rothamsted, Herts, and Dr. J. H. Gilbert, F.C.S.

On more than one occasion we have expressed our high sense of the important services rendered to the furtherance of fixed principles in agriculture by Baron Liebig. We have particularly called attention to the fact, that the masterly review of the then existing knowledge on the subject contained in his work entitled '*Organic Chemistry in its Applications to Agriculture and Physiology*,' and published in this country in 1840, had, more than any other circumstance, given that stimulus and direction to chemical inquiry, in connexion with agriculture, which has characterised the subsequent period. It was naturally to be expected, however, that the evidence to be derived from the inquiry that had thus been incited, would, in the progress of time, necessitate the modification or extension of the expression then given to the relations of science with practice.

In his third edition, indeed, published in 1843, Baron Liebig himself announced, in his Preface, that he had, in the years which had elapsed between that edition and his first, endeavoured to make himself "acquainted with the condition of practical farming, and with what it requires, by a journey through the agricultural districts of England and Scotland"—and also in that interval instituted a long series of experiments on the subject

in the laboratory at Giessen, with the sole object of giving a firmer basis to his "exposition of the causes of the advantageous results attending the practice of rotation of crops, and also of effectually banishing all doubts concerning their accuracy." He goes on to say, "*I am now, for the first time,* since the completion of these labours, in a situation to give a simple and determinate expression to my views of the origin of animal excrements, and of the cause of their beneficial effects on the growth of all vegetables." And he adds: "*Now that the conditions which render the soil productive, and capable of affording support to plants, are ascertained,* it cannot well be denied, that from chemistry alone all further progress in agriculture is to be expected."

After this announcement, it would have been unfair to Baron Liebig, to have attributed to him in any discussion, the views of his earlier editions, on points wherein he had modified them in his later ones. With this feeling, whenever we have, in our various papers, pointed out wherein it appeared to us that Baron Liebig's doctrines, as applied to *agriculture as it is*, required either modification or correction, we have invariably discarded all reference to his earlier published views, and assumed as our starting-point those given in his later editions, for which he claims a firmer basis and a greater certainty.

Baron Liebig, however, as it would appear, without having at that time read our own statement of our views, but only that summary of them given in a few lines by the late Mr. Pusey, devoted a note of some pages to a notice of our conclusions as so given. He expresses himself thus:

"With regard to the experiments of Mr. Lawes (the best authority, according to Mr. Pusey), they are entirely devoid of value, as the foundation for general conclusions. With a knowledge of our experience of the effects of fallow, and of production on the large scale, it requires all the courage derived from a want of intimate acquaintance with the subject to assert, that *certainly* ammonia is peculiarly fitted for *grain*, and *phosphorus* for *turnips*, and that manuring with straw is *probably* advantageous for turnips."—*Letters*, 3rd edition, p. 480.

Now, although Mr. Pusey was, perhaps, more competent than any other practical agriculturist to speak to the wants of British farming, yet the terms used by him were by no means those which we ourselves should have employed; and it was obviously unfair in any writer to take his statement of our views, rather than that which we have ourselves given of them.

But, nevertheless, so fully satisfied were we of the conclusions intended to be expressed by Mr. Pusey—*in the language and in the connexion in which we have ourselves given them in our Papers*—that we felt it incumbent on us to reply to such emphatic condemnation of our experiments and conclusions,

by one whose opinion, if founded on fair and careful criticism, should have so much weight as that of Baron Liebig. Hence it was that, in 1851, we published in this Journal, in a Paper entitled '*Agricultural Chemistry, especially in relation to the Mineral Theory of Baron Liebig*,' an answer to his strictures above referred to.

It is in reply to our Paper, just mentioned, that Baron Liebig, in the spring of the present year, published a short treatise entitled '*Principles of Agricultural Chemistry, with special reference to the late Researches made in England*,' which has been circulated very freely in Germany, France, England, and America. Nearly the whole of this treatise is devoted to a critical examination, in some form or other, of the experiments made at Rothamsted —of the opinions to which, by these and other facts, we have been led—and of our representations of the author's views, as distinguished either from the expression which he claims himself to have given to them in his former works, or from that which he would at present assign to them. He accuses us at once of *not having read*, of *misunderstanding*, and of *misstating* his views. He asserts that we have *disproved* that which we intended to *prove*; that we have *proved* that which we intended to *disprove*: and, in fact, that *our results in all points confirm the truth of his doctrines*, as announced in his works.

These are certainly rather serious charges. But not only have they been made under the incitement of controversy, by Baron Liebig himself, but they have been deliberately endorsed, in a Preface, by Professor Gregory, the English editor of Baron Liebig's work, in a manner so inconsistent with the obvious facts and justice of the case, that one can hardly be otherwise than amused at the zealous partisanship which could alone account for his extraordinary assurances. But this is not all. Periodicals, unconnected either with chemistry or agriculture, have, upon the credit of the high authorities referred to, taken for granted the truth of their statements; and thus they have been echoed, unexamined, through the general press. It is only due, therefore, both to ourselves, and to the large body of intelligent agriculturists who have from time to time expressed their confidence in the conclusions emanating from Rothamsted, and who have in so marked a manner acknowledged their sense of the value of the experiments upon which they are founded, that we should fully vindicate, not only the opinions themselves, but our integrity and honour in dealing with those of others, which have thus been called in question in such high quarters.

We cannot but regret on many grounds, that it should have become necessary to treat of our important subject much more in the controversial form than we had at first designed. It

will, however, be our endeavour to turn the course which has thus been forced upon us to as good account as possible, by making the execution of this part of our task the occasion of bringing before our readers a review of the published views, not only of Baron Liebig and ourselves, but of distinguished authorities both in this country and abroad, who have pronounced on the points involved.

The plan we propose is as follows :—

1st. To show, by copious quotation, both from Baron Liebig's previous writings and our own, what really have been the published opinions and doctrines of the former, and how far our own statements of those opinions and doctrines are justified by his own words.

2nd. To show how his views have been understood and interpreted by other writers than ourselves, not only in this country, but in Germany, France, and America.

3rd. To examine Baron Liebig's statements and criticisms of our experimental evidence and conclusions regarding the growth of *wheat* and *turnips;* and to adduce further evidence and arguments in support of the conclusions which we really have maintained on the points involved.

4th. To illustrate, by condensed summaries of an immense mass of experimental results, some prominent points of interest, connected with the *action of manures on the different crops of rotation*, and with the chemical circumstances involved in *fallow*, and a *rotation of crops.*

And lastly, throughout our observations we shall take occasion to point out the material admissions which are to be discovered in the newly published opinions of Baron Liebig; which show, that, notwithstanding there are still points of difference between us, we have now at least the sanction of his almost unequalled sagacity for the judgment which we have pronounced on certain points, as distinguished from the opinions formerly so prominently advocated by him.

Firstly, then, as to the consistency of our statements of Baron Liebig's doctrines, with his own statements of those doctrines. One of his chief complaints against us on this head, is in reference to a sentence occurring in one of our Papers; we quote it below. But we must here call attention to the inaccurate manner in which Baron Liebig makes his quotations; not only in the case immediately under consideration, but in many others, some of which we shall have occasion to point out. A similar want of accuracy is observable in his quotations both from Professor Wolff and Mr. Way, in the course of this same controversy. The portion which we give in brackets, thus [ ]

occurs in the original, but is not given by Baron Liebig in his apparently continuous quotation from our Paper.

"In the course of this inquiry, the whole tenor of our results, [*and also of information derived from intelligent agricultural friends, upon every variety of land in Great Britain*], has forced upon us opinions different from those of Professor Liebig on some important points; and more especially in relation to his so-called 'mineral theory,' which is embodied in the following sentence, to be found at page 211 of the third edition of his work on Agricultural Chemistry, where he says, 'The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure.'"—*Journal of the Royal Agricultural Society of England*, vol. xii. part i. p. 2.

With regard to the omission made by Baron Liebig in his quotation, we will only here observe how important is such an omission, when one of the main objections which Baron Liebig alleges against our conclusions is, that they are founded upon *our own experiments alone*, and without any consideration of what would happen *on other soils and in other localities!*

Baron Liebig also complains that the sentence which we have quoted as embodying his own doctrines, has been detached from its natural connection with a series of sentences, and thus a meaning given to it quite different from that intended by its author. In proof of this, he gives the sentence in question with its context, and also comments, to which we shall call attention. But here we must once more beg the notice of the reader to Baron Liebig's inaccurate mode of giving a quotation for the purposes of controversy, within unbroken inverted commas. We give the sentence, from p. 210 of the 4th edition of Baron Liebig's '*Chemistry in its Applications to Agriculture and Physiology*,' from which he himself professes to quote. The two first portions which we give between brackets, thus [ ], occur in the original, but are omitted in Baron Liebig's quotation; and the word "*the*" so inclosed is given in the quotation, but does not occur in the original:—

"Hence it is quite certain, that in our fields, the amount of nitrogen in the crops is not at all in proportion to the quantity supplied in the manure, and that [*the soil cannot be exhausted by the exportation of products containing nitrogen* (*unless these products contain at the same time a large amount of mineral ingredients*), *because the nitrogen of vegetation is furnished by the atmosphere and not by the soil. Hence also*] we cannot augment the fertility of our fields [*or their powers of production*], by supplying them with manures rich in nitrogen, or with ammoniacal salts alone. The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it *in* [*the*] *manure*."

The reader will perceive more clearly as we proceed, the importance of the omissions made in the quotation of the above sentence, bearing, as they do, both upon the question of what were Baron Liebig's opinions as to the dependence of

plants upon the *atmosphere*, and *not upon the soil*, for their nitrogen in *agriculture* as distinguished from normal vegetation—and upon the distinctions which he seeks to draw, between *fertility* (as implying duration) and *immediate production* merely.

But upon the sentence in the altered form, Baron Liebig says:—

"In the sentences just quoted from my book, the produce of the land is compared with the proportion of nitrogenous matter, inclusive of mineral substances, supplied *in the manure*, and with the amount of mineral constituents, inclusive of nitrogenous substances, supplied *in the manure*.

"The words '*by ammoniacal salts alone*' and '*in the manure*' show that I never thought of excluding carbonic acid and ammonia in the manure. According to Mr Lawes's mistaken notion of my meaning, I ought to have said, omitting the word *manure*, that '*on the contrary the fertility of the land rises and falls with the amount of mineral substances supplied to it*.' But this I have not said.

"The meaning of these sentences in my work is this: '*that ammoniacal salts alone*' *have no effect; that, in order to be efficacious, they must be accompanied by the mineral constituents, and that the effect is then proportional to the supply, not of ammonia, but of the mineral substances*."—*Principles of Agricultural Chemistry*, p. 54, 55.

Now, in reference to Baron Liebig's third paragraph of comment, it may be observed that, inasmuch as in the original he speaks of "manures *rich in nitrogen*," as well as "ammoniacal salts *alone*," the statement that he meant merely "*that ammoniacal salts alone have no effect*," is obviously quite inadmissible; whilst the introduction of the definite article "*the*" is the only foundation for the meaning claimed by Baron Liebig that he only included manure containing both nitrogenous matter and mineral substances—and that he did not speak of the fertility of the land rising and falling "with the amount of the mineral substances supplied to it." But he himself admits in another page (*Principles*, 115) that he *did* refer to manure generally, whether "*mineral* manure, guano, poudrette, farmyard manure, &c."

Whatever may have been the meaning of Baron Liebig in the sentence we have quoted, or whatever the interpretation which he now gives it, we shall presently make such full quotation from the same edition of his work, and from other publications, and also from other authorities, as will enable the reader to judge for himself—not only what was the obvious meaning of the sentence in question, but what has been the interpretation of that sentence, taken in connection with many others in his writings, by others of his readers than ourselves.

Before doing this, however, we will give a single illustration of how fundamental was the change made by Baron Liebig from the first edition of his work, to the third and fourth and subsequent publications; as by this means, the reader will not only be prepared to form a right judgment of what we shall have after-

wards to quote, but the unscrupulous unfairness of an anonymous article in the Journal of the Highland Society will be fully apparent. We have already shown how distinctly, in the Preface to his third edition, Baron Liebig admitted a change and perfecting in his views since the first. And yet, incredible as it may appear, our Northern critic admittedly makes his quotations by which to fasten the accusation of misrepresentation upon ourselves, from Baron Liebig's *first* edition, and from his 'Principles,' lately published *in the course of the controversy!*

One of the quotations made by this critic, with a view of showing that we have misrepresented Baron Liebig, in attributing to him an inadequate appreciation of the importance of available nitrogen *within the soil itself* for the growth of some of our most important crops in *agricultural quantity*, he takes from the *first* edition, as given below. We give by its side the sentence as it occurs in Baron Liebig's *third* and *fourth* editions; and the capitals are our own, to draw attention to the words altered from the earlier edition to the later ones.

"Cultivated plants receive the same quantity of nitrogen from the atmosphere as trees, shrubs, and other wild plants; BUT THIS IS NOT SUFFICIENT FOR THE PURPOSES OF AGRICULTURE."—*1st Edition*, p. 85.

"Cultivated plants receive the same quantity of nitrogen from the atmosphere as trees, shrubs, and other wild plants; AND THIS IS QUITE SUFFICIENT FOR THE PURPOSES OF AGRICULTURE."—*3rd and 4th Editions*, p. 54.

Notwithstanding, then, that in his third and fourth editions, Baron Liebig exactly reverses the opinion held in his first, on the very point in reference to which the sentence is brought against us—yet it is from the *first* edition that our critic quotes! In this *slight* alteration, too, we have a key to the fundamental change in Baron Liebig's views in regard to the capability of a liberal supply of the constituents proper to the soil itself—*the mineral constituents*—to enable plants to obtain from the atmosphere "*sufficient*" nitrogen for an *agricultural* amount of crop.

We shall now assume that we have given evidence enough of a change in Baron Liebig's views from his first edition to his later ones, to show that it is quite inadmissible to quote from his *earlier* in judgment of our representations of his *later* opinions. The following is the manner in which we have ourselves represented those opinions in reference to the point referred to by the critic in the 'Highland Society's Journal' and also by a writer in the 'Saturday Review' of November 10, 1855, *et seq.*:—

"*Practical agriculture consists in the artificial accumulation of certain constituents to be employed either as food for man or other animals, upon a space of ground incapable of supporting them in its natural state.* This definition of agriculture is, I think, important, as distinguishing English agriculture at least, from the system pursued in various parts of the world, where the population is small and the land of little value, viz., of taking only the natural pro-

duce of the soil, without any effort to increase it, and in time abandoning it for a soil as yet undisturbed. If Liebig had sufficiently considered this distinction, he would not have assumed that certain substances employed as manures are of little value, because plants and trees, in their natural state, are capable of obtaining them in sufficient quantity for their use."—*Journal of the Royal Agricultural Society of England*, vol. viii. part i. p. 227-8.

"The atmosphere and the virgin soil being originally the exclusive sources, the former of the '*organic*,' and the latter of the '*inorganic*' or '*mineral*' constituents of plants, it has been supposed that the amount of produce which a given space of ground would yield must depend upon its richness in those substances proper to itself, namely, the mineral constituents; and that these being supplied in full quantity, according to the indications of the analyses of the ashes of the crops it is wished to grow, the atmosphere would always prove an ample available resource for the more peculiarly vegetable matters. It will be readily understood that on such a view as this, economy in agriculture would be attained by a very different course of practice from that required were it to be shown that cultivation should effect an artificial accumulation in the soil of those constituents primarily derived from the atmosphere, rather than of such as more especially belong to its own constitution.

"The theory referred to has led to the analysis of the ashes of a great many agricultural crops, and upon the data thus obtained (rather than upon a consideration of the requirements actually induced by an artificially enhanced vegetation, or of the real source and destination of the constituents under a course of practical agriculture), recommendations to the agriculturist have been founded, the validity of which it was desirable should be tested by actual experiment, as well as by the presumed dictates of experience."—*Ib.* vol. viii. part ii. p. 535.

"It is true that, in the case of vegetation in a native soil, unaided by art, the mineral constituents of the plants being furnished from the soil, the atmosphere is found to be a *sufficient* source of the nitrogen and carbon; and it is the supposition that these circumstances of *natural vegetation* apply equally to the various crops when grown under *cultivation* that has led Baron Liebig to suggest that, if by artificial means we accumulate within the soil itself a sufficiently liberal supply of those constituents found in the ashes of the plant, essentially soil constituents, we shall by this means be able in all cases to increase thereby the assimilation of the vegetable or atmospheric constituents in a degree sufficient for agricultural purposes. But agriculture is itself an *artificial* process; and it will be found that, as regards the production of wheat more especially, it is only by the accumulation within the soil itself of nitrogen, *naturally* derived from the atmosphere, rather than of the peculiarly soil-constituents, that our crops of it can be increased. Mineral substances will indeed materially develop the accumulation of vegetable or atmospheric constituents when applied to *some* of the crops of rotation; and it is thus chiefly that these crops become subservient to the growth of the cereal grains; but even in these cases it is not the constituents, *as found collectively in the ashes of the plants to be grown*, that are the most efficient in this respect; nor can the demand which we find thus made for the production of crops in *agricultural quantity* be accounted for by the mere idea of supplying the *actual* constituents of the crop. It would seem, therefore, that we can only arrive at correct ideas in agriculture by a close examination of the actual circumstances of growth of each particular crop when grown under cultivation."—*Ib.* vol. xii. part i. p. 6, 7.

But there is another sentence in one of our Papers in which we have sought to indicate Baron Liebig's views, against which he strongly protests. It is as follows:—

"In conclusion, then: if the theory of Baron Liebig simply implies that the growing plant must have within its reach a sufficiency of the mineral constituents of which it is to be built up, we fully and entirely assent to so evident a truism; but if, on the other hand, he would have it understood that it is of the mineral constituents, as would be *collectively* found in the ashes of the exported produce, that our soils are deficient relatively to other constituents, and that, in the present condition of agriculture in Great Britain, 'we cannot increase the fertility of our fields by a supply of nitrogenized products, or by salts of ammonia alone, but rather that their produce increases or diminishes, in a direct ratio, with the supply of mineral elements capable of assimilation,' we do not hesitate to say that every fact with which we are acquainted, in relation to this point, is unfavourable to such a view."—*Ib.* vol. xii. part i. p. 39.

The comments Baron Liebig makes on this sentence are as follows:—

"In the first part of this quotation Mr. Lawes admits the truth of the so-called mineral theory; in the second I find two erroneous statements the continued diffusion of which I can no longer tolerate."—*Principles*, p. 115.

In the first part, then, of this comment by Baron Liebig, we have the important admission, that the so-called "Mineral Theory" —*as he would now have it understood*—"simply implies that the growing plant must have within its reach a sufficiency of the mineral constituents of which it is to be built up." And if it should be shown by the copious quotations which we have yet to make from Baron Liebig's former writings, that his *earlier* "Mineral Theory," as applied to *agriculture*, was far more correctly indicated by the latter portions of our sentence, which Baron Liebig tells us he "can no longer tolerate"—if this be shown, we may congratulate ourselves on a very material limitation of his formerly promulgated opinions. We have here also the admission, that "*we* fully and entirely assent" to such a "Mineral Theory," as "simply implies that the growing plant must have within its reach a sufficiency of the mineral constituents of which it is to be built up." And in this latter admission Baron Liebig must surely be conscious of a rebuke to himself, for the pervading insinuation throughout his criticism of our views, that we have ignored the necessity of mineral constituents to plants. Thus he says—

"It is not easy to understand how Mr. Lawes could deduce from his results the conclusion '*that nitrogenized manures are peculiarly adapted for the culture of wheat*,' since such manures can only produce a favourable result if certain preliminary conditions, which Mr. Lawes has entirely disregarded, be fulfilled." —*Ib.* p. 79.

And again—

"Now, every one would suppose from this, that Mr. Lawes thought that the use of ammonia enabled us to dispense with that of mineral manure, founded on the knowledge of the composition of vegetable ashes, and that these, the ashes or mineral constituents, might be replaced by ammonia." . . .

"For if Mr. Lawes admit, that the mineral constituents are indispensable to plants, how can he maintain that these very mineral constituents are replaceable by ammonia, that is to say, that by means of ammonia we can altogether dispense with them?"—*Ib.* p. 89.

Baron Liebig is perfectly well aware, that the sentences he refers to, presupposed certain "*preliminary conditions*," and had reference simply to the *source* of the mineral constituents of plants in the ordinary course of agriculture. For those who have not read our Papers, however, we may say, that any such insinuation as that here intended by Baron Liebig, is emphatically condemned—not only by special sentences, such as those quoted above, but by the whole tenor of our writings—as Baron Liebig himself is well aware, if ever he have read them.

But to return to Baron Liebig's comments on that statement of his doctrines which he "can no longer tolerate," he says:—

"The concluding sentence ascribes to me the assertion that the produce of land is proportional to the supply or diminution of the available mineral constituents. *This I have never said.*"—*Ib.* p. 115.

Compare this with the quotation already given:—

"The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure."—*Agricultural Chemistry*, 3rd ed., p. 212.

Again Baron Liebig says:—

"With regard to the previous sentence, I find in my work only one passage in which I speak of the land of England in the sense understood by Mr. Lawes."—*Principles*, p. 115.

And in reference to this point he also says:—

"It is not difficult to refute the opinions of another, if we ascribe to him assertions which he has never made.

"It never occurred to me to assert that the land of Great Britain was deficient in the substances which are found together in the ashes of the crops raised on it, or that, on a soil naturally fertile, rich crops might not be obtained for several successive years, *by the use of ammoniacal salts alone.*"—p. 116.

Baron Liebig denies, then, that he has addressed himself to the resultant wants of *agriculture* as practised in Great Britain—that he has ever maintained that the fertility of our fields increases or diminishes in a direct ratio with the supply of mineral elements capable of assimilation—or that, it is in the mineral constituents, as collectively found in the ashes of the exported produce, that our soils are deficient relatively to other constituents.

We will now examine the foundation of these several assertions. And first in order to show, that it was not only AGRICULTURE (as distinguished from normal vegetation), but that it was agriculture

as practised in Great Britain, on which Baron Liebig has addressed the English public in his various writings, we say:—

That the title of one of his publications is—'Organic Chemistry *in its Applications to Agriculture* and Physiology.'

That of another is—'An Address to the Agriculturists of Great Britain, on the Principles of *Artificial* Manuring.'

And of another—'On *Artificial* Manures.'

That in the preface to the third and fourth editions of his main work, he states them to be put forth, after having endeavoured to make himself "acquainted with the condition of practical farming, and with what it requires, by a journey through the agricultural districts of England and Scotland."

We were justified then in concluding that Baron Liebig put forth his doctrines not only as applicable to normal vegetation, but to *agriculture* and to the existing condition and wants of agriculture as practised in *Great Britain.* We will now show, by quotations from his works, whether we have mis-stated his views on the following important points, viz.:—

The dependence of our *cultivated* plants, whether graminaceous or leguminous, upon *atmospheric sources* for their supply of nitrogen.

The direct dependence of the *amount of produce* on the available *mineral* food of plants within the soil.

The nature of the restitution to be made *from without* in a course of practical agriculture.

He says (4th edition, as already quoted)—

"Cultivated plants receive the same quantity of nitrogen from the atmosphere as trees, shrubs, and other wild plants; and this is *quite sufficient for the purposes of agriculture.*"—p. 54.

"It is obvious, therefore, that there is no deficiency of atmospheric food for the plants of these regions, *and there can be none for our own cultivated plants.*"—p. 167.

"Are the fields of Virginia, the fields of Hungary, *our own cultivated plants,* not able to receive it from the same sources as the wild-growing vegetation? Is the supply of nitrogen in animal excrements a matter of *absolute indifference?* OR DO WE OBTAIN IN OUR FIELDS A QUANTITY OF THE CONSTITUENTS OF THE BLOOD, ACTUALLY CORRESPONDING TO THE SUPPLY OF AMMONIA?"—p. 205. The capitals are Baron Liebig's own.

"Hence it is quite certain, that *in our fields,* the amount of nitrogen in the crops is not at all in proportion to the quantity supplied in the manure, and that the soil cannot be exhausted by the exportation of products containing nitrogen, (unless these products contain at the same time a large amount of mineral ingredients), *because the nitrogen of vegetation is furnished by the atmosphere, and not by the soil.*"—p. 210.

"Is fertility not quite independent of the ammonia *conveyed to the soil?* If we evaporated urine, dried and burned the solid excrements, and supplied to our land the *salts of the urine, and the ashes of the solid excrements,* would not the cultivated plants grown on it—the *gramineæ and leguminosæ*—obtain their carbon and nitrogen from the *same sources* whence they are obtained by the gramineæ and leguminosæ of our meadows? *There can scarcely be a*

doubt with regard to these questions, when we unite the information furnished by science to that supplied by the practice of agriculture."—p. 203.

These then are Baron Liebig's opinions, in his later editions, as to the equal independence of plants,—wild or cultivated,—graminaceous or leguminous—of assimilable nitrogen provided *within the soil.* We do not mean to say, that there are not both facts and opinions recorded in Baron Liebig's writings, totally incompatible with the series of sentences which we have quoted. But we leave the inconsistency to be explained by Baron Liebig himself.

We must here beg the reader's attentive recognition of the fact, that the subject of which both Baron Liebig and ourselves are speaking is *agriculture*, not normal vegetation—that we treat of "*cultivated*" land, not a mere sand-pit, or other circumstances (*agriculturally* speaking abnormal), under which every mineral constituent of the plant has to be artificially provided. It must not be forgotten that there are here certain "*preliminary conditions*," namely, a *cultivated soil*—one, therefore, which is supposed to contain a certain amount of the necessary food of plants; but in a more or less actively fertile condition, according to the original composition of the soil itself—its state of mechanical and chemical degradation—and the home-manuring and cropping to which it has been subject. What then are the circumstances, with these "*preliminary conditions*," under which produce in *agricultural quantity* is to be obtained? Baron Liebig says:—

"The ammonia of animal excrements exerts a favourable influence *only because it is accompanied by other substances necessary for its conversion into the constituents of the blood.* When these conditions are furnished with ammonia, the latter becomes assimilated. *But when the ammonia is absent from the manure, the plants extract their nitrogen from the ammonia of the air;* to which it is again restored by the decay and putrefaction of dead animal and vegetable remains."—p. 210, 211.

"But, at the same time, it is of great importance for agriculture, to know with certainty that the supply of ammonia is unnecessary for most of our cultivated plants, and that it may be even superfluous, *if only the soil contain a sufficient supply of the mineral food of plants, when the ammonia required for their development will be furnished by the atmosphere.*"—p. 212.

Referring to the mineral elements of the soil, Baron Liebig says:—

"If these elements are present in sufficient quantity, and in appropriate proportions, the soil contains the conditions which render *the plant* capable of absorbing carbonic acid and ammonia *from the air*, which is an inexhaustible store-house for them, and renders their elements capable of being assimilated by their organism. The agriculturist must, therefore, *confine himself* to giving to the field the composition necessary to the development of the plants which he intends to grow; it must be his principal task to supply and restore *all the elements required in the soil, and not only one*, as is so frequently done; the ingredients *of the air*, carbonic acid, and ammonia, the plants can, in most cases, procure without man's interference; he must take care to give to his

field that physical condition which renders possible and increases the assimilation of these ingredients *by the plant;* he must remove the impediments which diminish their effect."—*Address*—'*On the Principles of Artificial Manuring*'—p. 16.

"The duration of the fertility of a field depends on the amount of the *mineral aliments* of plants contained in it, and its productive power for a given time is in a *direct proportion* to that part of its composition which possesses the capacity of being taken up by the plant."—*Address*, p. 10.

"Practice in agriculture has taught us that the amount of vegetable matters on a given surface increases with the supply of certain substances, WHICH WERE ORIGINAL CONSTITUENTS OF THE SAME SURFACE OF THE SOIL, and had been removed from it by means of plants. The excrements of men and of animals arise from plants; they are exactly the materials which, during the life of the animal, or after its death, obtain again the same form that they possessed as constituents of the soil.

"We know that the atmosphere does not contain these materials, and that it does not replace them; we know further that, by their removal from the soil, an inequality of production is occasioned, and, finally, even a want of fertility; but that, *by the restoration of these materials, the fertility may be sustained, and even increased.*"—*4th Edition*, p. 164.

"*The fertilising power of manure can be determined by weight, as its effect is in a direct ratio to its amount in the mineral elements of the food of plants.*" —*Address*, p. 11.

The above quotations show what was the relative importance attached by Baron Liebig to the nitrogenous and the mineral constituents of manure respectively; and how far he has been misrepresented on this point, by the quotation from him of which he so much complains; namely, that "*the crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure.*"

We shall now proceed to point out what were the means insisted upon by Baron Liebig, as necessary to the *maintenance* and *increase* of production of *cultivated land;* by which a judgment may be formed, whether "it never occurred" to him "to assert that the land of Great Britain was deficient in the substances which are found together in the ashes of the crops raised on it." Baron Liebig says:—

"Is it conceivable, that a rich fertile land, with a flourishing trade, which has for centuries exported the products of its soil in the form of cattle and of corn, can retain its fertility, if the same trade do not restore to its land, in the form of manure, the constituents abstracted from it, and which cannot be replaced by the atmosphere? In such a case, would not the same fate await this land as that which befel Virginia, upon the soil of which wheat and tobacco can no longer be cultivated?"—*4th Edition*, p. 164, 165.

Speaking of phosphate of lime and the alkaline phosphates, he says:—

"An enormous quantity of these substances indispensable to the nourishment of plants, is annually withdrawn from the soil and carried into great towns in the shape of flour, cattle, &c. It is certain that this incessant removal of the phosphates must tend to exhaust the land and diminish its capability of producing grain. The fields of Great Britain are in a state of progressive exhaustion from this cause, ..."—*Letters*, p. 522.

"If it were possible to restore to the soil of England and Scotland the phosphates which during the last fifty years have been carried to the sea by the Thames and the Clyde, it would be equivalent to manuring with millions of hundredweights of bones, and the produce of the land would increase one-third, or perhaps double itself, in five to ten years."—*Ib.*, p. 523.

"If a rich and cheap source of phosphate of lime and the alkaline phosphates were open to England, there can be no question that the importation of foreign corn might be altogether dispensed with after a short time."—*Ib.*, p. 524.

"It has been mentioned in the preceding part of the chapter, that animal excrements may be replaced in agriculture by other materials containing their constituents. Now, as the *principal action of the former* depends upon their amount of *mineral food* so necessary for the growth of cultivated plants, it follows, that we might manure with the mineral food of wild plants, or, in other words, WITH THEIR ASHES; for, these plants are governed by the same laws, in their nutrition and growth, as cultivated plants themselves. Thus, *these ashes might be substituted for animal excrements*; and if a proper selection were made of them, we might again furnish our fields with all the constituents removed from them by crops of cultivated plants."—*4th Edition*, p. 182, 183.

Speaking of the exhaustion of alkalies by the growth of wheat and tobacco in Virginia, he says:—

"*Almost all the cultivated land in Europe is in this condition.*"—*4th Edition*, p. 118.

"It is also of importance to know, that the rule usually adopted in France and in Germany of estimating the value of a manure according to the amount of its nitrogen, is quite fallacious, and that its value does not stand in proportion to its nitrogen.

"By an exact estimation of the quantity of ashes in cultivated plants, growing on various kinds of soils, and by their analysis, we will learn those constituents of the plants which are variable, and those which remain constant. Thus also we will attain a knowledge of the quantities of all the constituents removed from the soil by different crops.

"The farmer will thus be enabled, like a systematic manufacturer, to have a book attached to each field, in which he will note the amount of the various ingredients removed from the land in the form of crops, and therefore how much he must restore to bring it to its original state of fertility. He will also be able to express in pounds weight, how much of one or of another ingredient of soils he must add to his own land, in order to increase its fertility for certain kinds of plants.

"These investigations are a necessity of the times in which we live; but in a few years, by the united diligence of chemists of all countries, we may expect to see the realisation of these views; and by the aid of intelligent farmers, we may confidently expect to see established, on an immovable foundation, a rational system of farming for all countries and for all soils."—p. 212, 213.

Speaking of the importation of phosphoric acid into Great Britain in the form of bones, in ten years, he says:—

"To have increased the fertility of the fields in the right proportion, 800,000 tons of potash ought to have been added to the 1,000,000 tons of bones in a suitable form."—*Address*, p. 13.

"The fabrication of a manure, equal in its composition and effects to the solid and fluid excrements of animals and men, seems to me one of the most essential demands of our time, more especially for a country like England, in

which, from various circumstances, a rational agriculture, without a supply of manure in some shape or other *from without*, seems nearly impossible."—*Ib.*, p. 24.

Now, on what principles, and by what constituents, does Baron Liebig propose to provide England with a manure "*from without*," equal in its composition and effects to genuine guano, and to the solid and fluid excrements of animals and men? He goes on in the same page to say, "The following salts may be regarded as the essential constituents of a powerful manure applicable to all descriptions of soil." He then enumerates under this head, all the constituents indicated by analysis in animal manures, including, not only the mineral constituents, but *ammonia, decaying vegetable matter*, &c. But, immediately afterwards, speaking of the *mineral substances*, he says:—

"These are the substances which *together* give fertility to the soil; but although each of them may, under certain circumstances,—namely, where the soil is defective, or where it is not indifferent to the plant to take up one instead of the other, as, for instance, may be the case with soda instead of potass,—increase the fertility, no *one* of them can be regarded as manure, according to the common meaning of the word, for the simple reason, that only *all of them, in certain proportions*, will fulfil the purpose for which the common manure is applied. This purpose is the restoration, or an increase of the original fertility, and by manure we must replace *all the constituents of the plants which have been taken away in the harvest*, or which are *contained in the plants which we are desirous to cultivate*."—*Ib.*, p. 26.

Having thus stated the principle upon which a manure *from without*, and to replace guano and the solid and fluid excrements of animals and men, should be compounded, he says:—

"What, then, are the constituents of the soil which we remove by the straw, seeds, tuberculous roots, stalks, &c., of our plants of culture? It is obvious that we must know these first, in order to *restore them in sufficient quantities*. To this we answer, by giving *the analysis of the ashes of plants and their seeds*."!!

After this overwhelming amount of evidence on the point—culminating as it does to an almost exact reflection of what we have assumed in our Papers to be the *Mineral Theory* of Baron Liebig as applied to agriculture—after all this evidence from his own writings, we need scarcely ask:—

Is there in the sentence of our Paper, of which Baron Liebig so much complains—is there, we ask, in that sentence, that of which he should say:—

In it—"I find two erroneous statements, the continued diffusion of which I can no longer tolerate"?

Or is he justified in asserting that he has never said—"That the produce of land is proportional to the supply or diminution of the available mineral constituents"?

That—"I find in my work only one passage in which I speak of the land of England in the sense understood by Mr. Lawes"?

That—"It is not difficult to refute the opinions of another, if we ascribe to him assertions which he has never made"?

And that—"It never occurred to me to assert that the land of Great Britain was deficient in the substances which are found together in the ashes of the crops raised on it," &c.?

Or, need we further ask—Where is the *Oxford version** of the "Mineral Theory,"—namely, that "it throws upon the air, *or upon the ingredients of the manures which are organic in their origin*, the task of furnishing nitrogen to the plant"—where is there any trace of *this version* of the "Mineral Theory" in the overwhelming amount of Baron Liebig's own definitions of his peculiar doctrines which we have been quoting?

Secondly. We will now show how Baron Liebig's so-called "Mineral Theory" has been understood by other writers than ourselves, not only in England, but in Germany, France, and America.

Dr. Muspratt, formerly a pupil of Professor Liebig at Giessen, now Professor of Chemistry at Liverpool, and a son of the gentleman of that name who undertook the manufacture of Baron Liebig's manures in this country, commenting on a lecture by Mr. Karkeek, in which he had detailed the results of some experiments with Baron Liebig's manures, says:—

"It has long since been established that when the inorganic ingredients are *all* present, and in *sufficient quantity*, the carbon and nitrogen *the plants can assume from the air* without the interference of the farmer, if the land be in that physical condition which is requisite for the assimilation of the ammonia and carbonic acid present *in the atmosphere*."—*Mark Lane Express, March* 1, 1847.

Mr. Karkeek, in the course of his reply to Dr. Muspratt, thus indicates what he understands is the doctrine of which Dr. Muspratt was the representative:—

"Taking, then, these three experiments as they stand, and well knowing that the Trewithen meadow had been very highly manured for a long time, while the contrary was the case in the other two instances, I consider that I was not much out of the way in stating my opinion that the failure of Liebig's manure was the consequence of a want of sufficient quantity of azotised and (it should have been reported) carbonised matters in the soil; and whatever Dr. Muspratt may think to the contrary, notwithstanding I have such high authority to contend with, yet from the practice which I have had in observing the effects of various kinds of artificial manures during the past five years, I am quite satisfied that the inorganic elements are of very little value as a manure for plants without a corresponding supply of the organic. Indeed I am of opinion that plants have neither the power of assimilating the inorganic elements in the soil, nor the organic substances from the atmosphere in such a degree as to enable the farmer to grow twenty tons of swedes to the acre, unless they are also supplied with a proper quantity of carbonaceous and azotised substances at the same time."—*Mark Lane Express, March* 22, 1847.

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* See Saturday Review of Nov. 10 and Dec. 1, 1855, *et seq.*

Again, the Council of the Royal Agricultural Society of England undertook a series of investigations as to the composition of the *ashes* of agricultural plants, with the object, in accordance with the doctrine of Baron Liebig, of ascertaining the manures required to restore to land its productive capability lost by the removal of previous crops, or to prepare it for the subsequent growth of this or that agricultural plant. In the course of this inquiry their able chemist actually provided recipes on the principle alluded to. But, as we well know, his own judgment and sagacity led him to doubt the sufficiency of the plan submitted to him to answer the ends supposed, long before his task had been concluded. Nor need we remind the reader, that investigations of a similar kind, and instigated by the same suggestions, have been made in many of the European laboratories with the same object; or further, that an immense number of manure-making schemes have arisen in England, Germany, France, and America, professedly founded on the principle alluded to.

In the 'North British Agriculturist' of November 7, 1855, the editor thus defines Baron Liebig's views:—

"Now, according to Liebig, ammonia is always afforded by the atmosphere in excess, while mineral matters, if not always, are at all events generally deficient in the soil; hence his inference is, that in order to increase the crop, it is only necessary to add the latter. He does not assert that ammonia is useless: on the contrary, he would have every farmer to add it to his soil, and that abundantly, if he happens to possess it; but if he proposed to lay out a certain sum of money in the purchase of manures, he would counsel him to expend it on *mineral matters*, and trust *to the atmosphere for the ammonia*, which he believes may be obtained from it in quantity *more than sufficient* for *the largest crop which it is possible to obtain.*"

Professor Johnston, in a lecture delivered at the York Meeting of the Royal Agricultural Society, in 1848, says:—

"A third opinion adopted by many, and extensively acted upon by some, is, that plants obtain all their organic matter *directly from the air*, and derive, and therefore require, *only mineral matter from the soil.** "—*Jour. Roy. Agr. Soc. Eng.*, vol. ix. part 1, p. 223.

And, in a note to which attention is drawn by the star given at the end of his sentence, Professor Johnston gives the very sentence from Baron Liebig, which we are ourselves so much complained of for quoting, thus:—

"* 'The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure.—*Liebig.*' "

In France—M. Boussingault, whose competency to judge of such matters is second to none in that country, and whose high character and authority as a philosopher and an agricultural chemist no one will doubt, thus indicates both his understanding and his opinion of Baron Liebig's doctrine—

"The view which assumes that the saline substances which manures contain, are their only really useful constituents, would lead to advising farmers to burn their manure heaps in order to diminish the carriage, always such an inconvenience and so costly. I question whether this advice would ever be followed. Moreover, careful observation has shown that the organic substances in manure exert a very marked effect. Thirty square metres of infertile clay soil were manured with farm-yard manure, and yielded a very good crop of oats. By the side of this, on an equal surface, were spread the ashes (the salts therefore) of an equal quantity of the same manure; by so doing the produce was not sensibly increased."—*Economie Rurale*, vol. ii. p. 81-2 (Translated).

Another able French writer, M. Puvis, in his 'Traité des Amendements,' says (we give the passages translated)—

"Humus, in a soluble state, would be the peculiar food of plants, and would, moreover, furnish tnem with an incessant supply of carbonic acid, as the illustrious chemist of Giessen himself admits, though at the same time he calls in question the necessity of animal manures."—p. 423.

"The illustrious chemist of Giessen, having formerly admitted, in common alike with practical men and theorists, that ammonia is an essential and necessary constituent of manure, now regards it (ammonia) as one of the constituent principles of atmospheric air, and maintains that plants will derive it thence according to their requirements, as they do carbonic acid."—p. 623.

"He then goes on to express a hope that the time may come when saline matters in small bulk will be substituted for animal manures."—p. 624.

"In his new system he would almost exclude nitrogen, which however practical experience teaches us to look upon as one of the most active agents of production."—p. 624.

"Since the chemist of Giessen, Liebig, has proposed to replace the manure heap by small quantities of saline substances, and has himself set the example of the sale of these substances, propositions for new manures have rained upon us in all parts of Europe; in France, much more than elsewhere, manufacturing processes have risen up in all directions, to replace stable and other powerful manures by substances either in powder or in the liquid state, of a bulk fifty or one hundred times less than even the smallest quantities of manures which experience had sanctioned. Since 1842 we may reckon eighty-six patents of inventions for new manures, and all promise the highest productiveness."—p. 627.

"The chemist of Giessen has adopted the fundamental principle of the system of Duhamel, namely, that plants derive from the atmosphere all the volatile principles which enter into their composition; but considering that plants also contain fixed mineral principles which are not found in the atmosphere, and that successive crops would soon deprive the land of these substances necessary to vegetable organization, he has thought it necessary to add to the system of Duhamel, as a necessary condition, that we must give to the soil the *mineral substances according to the composition of the crop that we wish to produce.* Convinced of the justice of his theory he thought to profit by it, and accordingly artificial manures modified to suit the nature of the soil, and the kind of crops, were sold under his name in Germany and England; the name of the distinguished chemist ensuring in these two countries a great number of trials, to which nothing in general was wanting but success."—p. 632.

"After the failures resulting from the use of the Liebig manures they were soon abandoned, and the analogous composts to which they had given rise, also quickly fell into discredit."—p. 635.

In Germany,—numerous writers have told us how they under-

stand Baron Liebig's doctrine; we quote from a few of these, some of whom have also given their opinion as to the truth of that doctrine.

Professor F. G. Schulze, of Jena, thus defines Baron Liebig's theory (we quote from p. 204 of the 'Patent Office Report' for 1848; Washington, 1849):—

"The stable manure which agriculturists furnish, essentially aids vegetable life, only by what it contains of alkalies, lime, silica, and other mineral elements, not by what it contains of carbon, hydrogen, oxygen, and nitrogen, for these substances plants can obtain from the air, as an inexhaustible source. As now in stable manures, the mineral elements bear the proportion of some two to seven per cent. of the whole mass, so the agriculturist, who yearly brings on his fields 100,000 cwt. of stable manure, carries out 93,000 to 98,000 cwt. in vain. It would be far more simple and less costly to give the plants only mineral manures, and to leave them to acquire their organic means of nutriment from the air."

"In the burning of plants, the organic, not the inorganic portions, are dissipated. Hence the agriculturist can burn his crops, namely, his straw, and yet continue his fields in the strength hitherto possessed, if he only carries on the ashes acquired by such burning. But if circumstances do not permit him to manure the plants with such ashes, yet can the same object be attained, if by the aid of chemistry he will examine into the ash constituents of his harvest, and carry the mineral substances corresponding to his analysis upon his field."

Dr. Weissenborn, of Weimar, in an article entitled 'Observations on Liebig's Patent Manure; with a Comparative View of the *Theories* of Thaer and Liebig,' thus expresses himself in regard to Baron Liebig's principles:—

"The *great rule* of the new system of manuring is the following:—Let the fields not be manured with stable-dung, nor with any sort of dung whatever that contains organic (vegetable or animal) substances, along with its inorganic (mineral) principles. This mineral manure the farmer has to procure, either by incinerating all the vegetable substances that he has reaped, and which he cannot profitably sell or consume on his farm, especially by burning the straw; or by applying to a chemist, with a view of having both the soil to be manured and the ashes of the plant to be cultivated duly analysed, and of getting prepared conformably to the result of such analyses an artificial manure (mineral manure, manure of ashes), containing the very mineral food that the plant wants, and that is not already contained in the ground."

"The *advantages* of the new system of manuring are represented to be the following:—

"1. The farmer saves almost the whole of the expenditure for transporting manure to the fields, as the weight of the mineral manure he wants is only 2·6 per cent. of that of the stable-dung hitherto used.

"2. On fields manured after the new system, the vegetation cannot materially suffer from want of rain.

"3. The straw may be sold; and most of the live stock, that scarcely ever yields a net revenue, may be dispensed with.

"4. The rotation of crops is rendered unnecessary, and any sort of crop may be raised on the same field without intermission.

"This *theory* of Professor Liebig is refuted by the following principal facts:" —&c., &c.—*Farmer's Magazine*, vol. xv., 1847, p. 369.

Professor Hugo von Mohl, in his 'Principles of the Anatomy and Physiology of the Vegetable Cell,' says :—

"Instead of reforming agriculture by his manures, Liebig has caused them to demonstrate the incorrectness of his *theory of the nutrition of vegetables*."—*English Translation*, p. 80.

Baron Liebig, in his 'Principles,' recently published (p. 121-123), professes to wonder where Professor Wolff "has found what he calls the *pure Mineral Theory?*" Dr. Wolff answers him as follows :—

"As Baron Liebig does not seem to understand how I became acquainted with the so-called '*pure Mineral Theory*,' founded and even yet defended by him, I will enlighten him. By the Liebig Mineral Theory every one understands the idea which was to be practically carried out in the patent manure, namely, that when a soil has become exhausted by one or more crops, the *mineral constituents* necessary for the food of plants shall be restored to it in sparingly soluble compounds, and in such proportions as a chemical analysis of the crop would indicate. By means of the patent manure the same plants might be grown uninterruptedly on the same land, and a succession of abundant crops obtained."—*Zeitschrift für Deutsche Landwirthe*, 4en Heft, p. 112 (Translated).

In America much discussion has taken place regarding Baron Liebig's views. But, to save space, we will only give one quotation in connexion with that country. In a letter to Professor Webster, Professor E. N. Horsford, whilst with Baron Liebig at Giessen, writes, under date May 1, 1846, as follows (we quote from the 'Genesee Farmer' of August, 1855) :—

"You are aware that Boussingault has expressed the opinion, after a variety of experiments, that the value of manure is in near relation to its percentage of ammonia. Mulder has, you know, written much in support of the view that ulmic and humic acids, ulmates, humates, &c., in one form and another, minister largely to vegetation. . . . . *Liebig differs from them all.* . . . . He takes the position, that the sources of carbon and nitrogen are carbonic acid and ammonia *in the air*. . . . .

"It is obvious (from analyses of soils and rain-water) that the ammonia spread on fields in the ordinary distribution of barn-yard products *is of no moment*. The quantity with usual falls of rain *greatly exceeds*, in the course of a season, any conceivable supply by human instrumentality. . . . .

"But if, in the manure-heap and the liquid accumulations of the barn-yard transported to the fields, the ammonia be not the chief ingredient, or *an important one*, to what are we to attribute the unquestioned value of stable products and night-soil? Professor Liebig has shown, that if plants be manured with the ashes of plants of the same species, as the grasses of our western country are when burned over in the fall, they are supplied with their natural food. . . . . . . Let us consider what these ashes are, and what manure is. Herbivorous animals derive their nourishment from the vegetable kingdom exclusively, their food being grass, grain, roots, &c. These, with their organic and inorganic matters, are eaten. A portion of them is assimilated, becoming bone, muscle, tendon, fat, &c. Another portion is voided in the form of excrementitious matter. In process of time the bones and tissue follow the same course. What to-day forms the eye, with its sulphur, and its phosphorus, and carbon, &c., will have accomplished

its office, and left the organism to mingle with the excrements, or escape as carbonic acid and water from the lungs. At length all the *inorganic matters* will re-appear in the voided products. . . . . . . The animal organism has performed the office of a mill. Grain was supplied. Instead of appearing as flour and bran, and the intermediate meal, it appears, after intervals of greater or less length, in soluble *inorganic salts* in the liquid excrements, in insoluble *inorganic salts* in the solid excrements, and in carbonic acid and water. Now, after burning a plant, what remains? It contained, when growing, carbon, nitrogen, hydrogen, and oxygen, as organic bodies, and water. It contained also, in variable proportions, common salt, potass, soda, magnesia, lime, iron, phosphorus, sulphur, and silica. The first four were expelled in the combustion. The remaining ingredients, for the most part, remained unchanged. Had the plant gone into the body of an animal, and in the course of its evolutions through the organism lost its carbon, hydrogen, nitrogen, and oxygen, the remaining ingredients would have been the same as before. In one case the plant would have been burned in the organism; in the other, in a crucible. *The ashes and the excrements are substantially the same.* . . . Night-soil and guano are the *ashes* of animal and vegetable organisms burned in animal bodies. They are the *ashes of plants*—the essential food of plants. *Hence their value as manures.*"

So much, then, for the consistency of the interpretations of other writers—English, French, German, and American—with the interpretations we have ourselves given of the Mineral Theory of Baron Liebig. And how, we would ask, are these interpretations consistent with those now claimed by Baron Liebig and his friends, namely, that "*The Mineral Theory*" "throws upon the air, *or upon the ingredients of the manure which are organic in their origin*, the task of furnishing nitrogen to the plants"?

Baron Liebig shall answer for himself, whether it is upon "*the manure*" that he throws "the task of furnishing nitrogen to the plant." This one quotation and we have done with these lengthy illustrations of Baron Liebig's views. In a letter to the Editor of the 'Revue Scientifique et Industrielle,' a translation of a part of which is given in the 'Farmer's Magazine,' vol. xvi. (1847) p. 511, from which we quote, Baron Liebig says:—

"It has been demonstrated that ammonia is a constituent part of the atmosphere, and that as such it is directly accessible and absorbable by all plants. If, then, the other conditions necessary to the growth of the plants be satisfied—if the soil be suitable, *if it contains a sufficient quantity of alkalies, phosphates, and sulphates, nothing will be wanting: the plants will derive their ammonia from the atmosphere as they do carbonic acid.* We know well that they are endowed with the faculty of assimilating these two aliments, *and I really cannot see why we should search for their presence in the manures we use.* . . . . . The question of the necessity for *ammonia in our manures* resolves itself into the question of the necessity for *animal manures*, and upon the solution depends the entire future prospects of agriculture; for as soon as we can dispense with bulky farm-yard manure, by the use of artificial preparations, the productive power of our fields is placed in our own hands."!

Thirdly—Having shown what was the "*Mineral Theory*" ad-

vocated by Baron Liebig prior to his recently published work, and how we and others have understood that theory as so advocated, we now pass on to the third main division of our subject; namely, to a consideration of the criticisms of our experiments and opinions regarding the growth of *wheat* and *turnips;* and, in the course of this inquiry, we shall endeavour, by the aid of the experiments quoted by Baron Liebig, taken with others by their side, to relieve the points which they are calculated to elucidate, of the mystery and confusion in which Baron Liebig has sought to envelop them.

In regard to our experiments on the growth of *wheat*, Baron Liebig says we have drawn the conclusions:—

1. "*That the mineral constituents of wheat cannot by themselves increase the fertility of land.*"

2. "*That the produce, in grain and straw, is rather proportional to the supply of ammonia.*"

We do not object to the definitions here given of our conclusions — *subject of course to the amplifications and qualifications which our own papers indicate.* But, notwithstanding in a public discussion on this subject, we utterly repudiated the definition of some of our conclusions assumed by Baron Liebig in summing up, and giving his verdict on our opinions at the end of his Treatise, he did not scruple to repeat those palpably incorrect interpretations of our meaning.

Let us now see, how it is that Baron Liebig seeks to show, that our own experiments contradict the above conclusions, Nos. 1 and 2.

Before we can do this, however, we must first clear the ground of a most ingenious objection, by which, as he cannot *deny* our facts, he would seek to throw them aside, as utterly unfit to be the foundation for any general conclusions regarding any other land than our own, or regarding agricultural practices generally.

Baron Liebig says,—

"Mr. Lawes has shown, in the most convincing manner, that in his land the mineral constituents of wheat were present in the greatest abundance and in an available form; and no one but Mr. Lawes himself can be surprised that, under such circumstances, by manuring with ammoniacal salts only, without any addition of mineral matter, he obtained during six years a higher produce than from the same land unmanured; for *theory plainly predicts such a result.*"—*Principles*, p. 78, 79.

"Mr. Lawes, then, as appears from these passages, chose for his experiments a portion of land which, on account of its being so rich in available mineral constituents, and of its other qualities, was utterly unsuited to his purpose, and which ought to have been unhesitatingly rejected, if the object was to test the value of the mineral food of plants. And since the mineral manure, in these circumstances, could not possibly have the effect expected by Mr. Lawes, his conclusions are destitute of all foundation in logic or in facts."—p. 59, 60.

Certainly, this is a very clever way of dismissing the whole of

our experimental evidence: and, in a similar manner, experiments on ten thousand different soils might be dismissed as exceptional, and therefore inapplicable to any other case than the particular one in which the result was obtained. In other words, the solution of general agricultural questions is not within the reach of field investigation!

But we propose to show, that *these assertions* are "destitute of all foundation in logic or in facts," and that the land in question was perfectly adapted to the object in view in the experiments; which was, not simply to test the value of the *mineral* food of plants, but to ascertain what was the nature of the manure required—mineral or otherwise—to restore the productive capability for the increased growth of corn, which had been exhausted by an unusually severe course of cropping on an *ordinary* soil, and which, in the *ordinary* course of management, would have had its productiveness again increased, by the use of the *ordinary* means of farm-yard manure, fallow, or green cropping.

We must repeat, then, that which we have reiterated so often that we are almost ashamed of again troubling our readers with the statement, namely, that whatever might be the quality of the soil selected (and it was certainly anything but one of the richest soils of Great Britain, as described by Baron Liebig), it *was* in a state of *practical* or *agricultural* exhaustion, when first submitted to experiment. That is to say, it had grown a course of turnips, barley, peas, wheat, and oats, since the application of manure; and it was by this treatment brought into such a condition of comparative or practical unproductiveness, that no farmer paying rent for it, and no landlord letting it, would allow it again to grow corn without manure in some form. It was, moreover, as we have already said, in such a state of *practical* or *agricultural* infertility, that the use of the *ordinary* means of manure, fallow, or green cropping, would very greatly increase its produce. And, whatever may be the opinion or the dictum of purely theoretical persons, however high their authority in their own department of knowledge, we do not hesitate to maintain before the intelligent practical man, that a soil which had been submitted to the exhausting treatment above described, and brought into the condition here stated, *was* in a fit and proper state for experimenting on with manures, in order to ascertain the nature of the exhaustion it had suffered by a course of agricultural cropping.

But, in order to *prove*, that the soil *was* in a state of agricultural exhaustion, and that it *was* in a condition to show the effects both of mineral and organic manures, we have arranged in the following Table (I.), a condensed summary of nearly the whole of

the results obtained in the field in question, during a period of eleven years of the successive growth of wheat.

TABLE I.

Summary.—Results of Experiments on the Growth of Wheat.
Average Total Produce, and Total Increase (Corn and Straw), lbs. per Acre.

Series.	General Description of Manures.	Number of Years.	Number of Cases.	Total Produce (Corn and Straw).	Total Increase (Corn and Straw).
				lbs.	lbs.
1	Unmanured	11	27	2864	..
2	Mineral Manure, only	8	40	3018	154
3	Farm-yard Manure	11	11	5036	2172
4	Ammonia-salts, only (Standard Amount)	9	36	4857	1993
5	Nitrate of Soda (= do. do.)	3	4	4907	2043
6	Ammonia-salts (= do. do.) with Minerals	9	117	5531	2667
7	Ammonia-salts and Rape Cake (= do. do.) do. do.	6	12	5540	2676
8	Ammonia-salts (less than Standard) do. do.	6	17	4536	1671
9	Ammonia-salts (more do. do.) do. do.	8	31	6445	3581
10	Ammonia-salts and Rape Cake (do. do. do.) do. do.	5	22	6016	3152

The plan of this Table (I.) is as follows. We have taken the average total produce per acre (corn and straw) of all the plots in each separate year which were unmanured, and then the average of these for the eleven years of the experiment: the number of cases in all, as seen by the Table, amounting to 27. In like manner the average is taken of all the cases in each year in which mineral manures alone were employed, and then the average of these results of the individual years, by dividing their sum by the number of years; and so on, with the cases where farm-yard manure, ammoniacal salts, or any of the other characteristic constituents or combinations, as indicated in the Table, were employed. The last column in the Table—that of total increase—represents the average annual total *increase* in lbs. (that is, corn and straw together), obtained from the manured over that of the unmanured plots.

We are not, it is true, favoured with any numerical statement whatever, either summary or in detail, of the experiments on the "Liebig's Height"; but we should not ourselves have thought of asking confidence in such a mere condensed summary as we now give, were it not that many of the results which go to form it, are already before the readers of this Journal, and the remainder we trust will be so in the course of time. This being so, we do not doubt that this summary will be accepted as both much more convenient, and better adapted for the discussion of the more prominent and characteristic facts, than a series of elaborate

tables of detail. Leaving, then, entirely out of the question, on this occasion, all detail or discussion as to the amount and specific description of the different manures, and also as to the varying proportions of corn and straw respectively, which make up the sum of the total produce, let us see what are the broad and main features brought out by this immense mass of experimental evidence.

The average annual total produce (corn and straw) per acre unmanured, including the results of eleven years, and extending in all to 27 cases, is 2864 lbs. The average annual increase over this amount, obtained by various purely mineral manures, in 40 cases, distributed over eight different years, is only 154 lbs. The increase by farm-yard manure on the other hand, taking the average of eleven years, is 2172 lbs. It is clear, therefore, that there are here 2000 lbs. of increased produce, beyond that which the mineral manures were adequate to yield. Again, it is seen (in Series 4), that the average of 36 cases of purely ammoniacal manure, gave an average increase over the unmanured plots of 1993 lbs.; whilst nitrate of soda, another manure whose efficacy is due to the nitrogen it supplies, and which was applied in quantity as nearly as possible equal in nitrogen to that of the ammonia-salts, has given a mean average increase of 2043 lbs.

In the next series (6), we have 117 cases, distributed over nine years, in which ammonia-salts were employed, in quantity equal in their contents of nitrogen to the ammonia-salts of Series 4, and the nitrate of soda of Series 5; but we have here (in Series 6), the addition to the nitrogenous manure, of various purely mineral manures; and the increase becomes 2667 lbs. instead of only about 2000 lbs. with nitrogenous manure alone; so that, with this combined mineral and nitrogenous manure, the produce considerably exceeds that by farm-yard manure. Whilst, then, an excessive supply of nitrogenous manure alone has produced an average increase of about 2000 lbs., the further addition of minerals has, when there was at the same time a large amount of *nitrogen artificially provided within the soil*, given a further average increase of 674 lbs.; though, when these minerals were added *without* an excess of nitrogen in the soil, the average increase they yielded was only 154 lbs.

It is seen then, that mineral manures alone, increased the produce of this agriculturally exhausted field in no practical degree; that pure nitrogenous manures increased it nearly as much as the ordinary manure of the farm; and that nitrogen together with minerals gave a produce nearly double that of the unmanured land, and considerably exceeded that by farm-yard manure. "*That the mineral constituents of wheat cannot by themselves increase the fertility of land*"—and "*that the produce in grain and straw is*

rather proportional to the supply of ammonia," would be conclusions from these simple facts, far more logical than many which we are expected to receive without any facts at all.

To proceed—May it not be said that the effect of the farm-yard manure upon the increased growth of wheat, was due in some way or other to its *carbonaceous* substance, rather than *chiefly* to its nitrogen, and to a *small extent* to its minerals in connexion with that nitrogen? This supposition is negatived by a comparison of the results of Series 7 with those already discussed, which throws some light upon the relative effects of the nitrogenous, the carbonaceous, and the mineral constituents of manure, upon the increased growth of wheat, on any corn-exhausted soil. Series 7 gives the average of 12 cases, distributed over six years, in which rape-cake, either with or without ammonia-salts, was employed in such quantity as to provide nitrogen exactly equal to the ammonia-salts of Series 6; and as in the latter, so also in Series 7, minerals were always added. We have here the striking result, of an average difference of produce of only 9 lbs. between Series 6 and Series 7, there being in the two cases an identity in amount of nitrogenous supply; and this, notwithstanding that the rape-cake employed in Series 7 would supply a considerable amount of additional minerals, and a large quantity of carbonaceous substance, neither of which have given an appreciable increase beyond that of the equivalent nitrogen and minerals of Series 6.

In Series 8 we have, together with the minerals, *less* ammonia-salts than in Series 6; and with this *less* amount of ammonia or nitrogen, we have only 1671 lbs. of increased produce, instead of 2667 lbs. as in Series 6. In Series 9, on the other hand, we have with the minerals, *more* ammonia than in Series 6, and also a considerably increased amount of produce; that is to say, when with the minerals we have applied a *larger* amount of ammonia in the manure than the "standard," we find an average annual increase of total produce per acre of 3581 lbs.; with only the "standard" amount of ammonia, an increase of 2667 lbs.; and with *less* ammonia than "standard," an increase of only 1671 lbs. And, finally, in Series 10, with minerals, rape-cake, and ammonia, containing together *more* nitrogen than in Series 6 and 7, we have, taking an average of 22 cases, and extending over a period of five years, an average increase of 3152 lbs.; instead of 2667 lbs. and 2676 lbs. in Series 6 and 7 respectively.

Surely in the results of this comprehensive summary of experimental evidence, we have good grounds for concluding, that this practically corn-exhausted field *was* in a condition to test the nature of that exhaustion, and of the constituents requisite to restore it to that condition of practical corn productiveness,

which the ordinary means of farm-yard manure, fallow, or green cropping would attain; and, if it be really so, there surely has been some light thrown, upon the important question of the source of the efficacy of these well-recognised practices, so far as the growth of grain is concerned.

The object of this inquiry really was, to determine by what constituents of manure the produce could be raised from the normal amount of its agriculturally exhausted state—no matter whether this was 17 bushels or 0—up to the point of which it was capable by the ordinary means of intelligent and successful farming. This is the practical question, the question for *agriculture*. And we repeat, that, inasmuch as by the means that were employed we obtained an increase per acre of 10 to 15 bushels or more, with its equivalent of straw, over the produce of the unmanured land, *whatever this last might be*—we say that, as this was the case, our soil was in a fit and proper state to elucidate the important agricultural question as to what was the nature of the exhaustion suffered by a course of agricultural cropping, and as to what constituents it was necessary to provide before the produce of grain could again be raised, from that of the *practically exhausted*, to that of the *practically fertile* condition of the land.

But Baron Liebig has said that, because we obtained an average produce of 1125 lbs. of grain and 1756 lbs. of straw, during seven consecutive years, that this was a sufficient proof—

"that the soil was naturally so rich in available mineral constituents, of the kinds required by plants, that manuring with 4 cwt. of mineral manure per acre, a quantity which, spread over the ground and mixed with the soil to the depth of 12 inches, gives 1 grain to 20 cubic inches of soil, could most certainly produce no effect, or, at the utmost, a very trifling one. For, in the first year, the soil contained seven times, or about 85 per cent. more of these substances than was required for one crop."—*Principles*, p. 58.

Now, if it really were so, that our "soil was naturally so rich in available mineral constituents of the kinds required by plants," as Baron Liebig admits, is it not the strongest condemnation which could possibly be conceived of the doctrine presented in so many forms to the farmer, namely, that "if only the soil contain a sufficient supply of the mineral food of plants," *then* "the ammonia required for their development will be furnished by the atmosphere"? Is it not, we ask, the strongest possible condemnation of such a view that, with the soil in this supposed naturally rich condition, the produce should still be *less*, by many bushels of corn, and their equivalent of straw, than that obtained on the simple addition of *available nitrogen to the soil?* And, when Baron Liebig *now* informs us that—

"no one but Mr. Lawes himself can be surprised that, under such circumstances, by manuring with ammoniacal salts only, without any addition of

mineral matter, he obtained during six years a higher produce than from the same land unmanured; *for theory plainly predicts such a result*"—*Principles*, p. 78—

we ask, is not this again the condemnation by Baron Liebig himself of his own *previously* insisted upon doctrines, as already shown in quotations from his works, and in other words in his letter to the editor of the '*Revue Scientifique et Industrielle*,' namely, that,

'if the soil be suitable, if it contains a *sufficient quantity of alkalies, phosphates, and sulphates, nothing will be wanting*; *the plants will derive their ammonia from the atmosphere*, as they do carbonic acid"? (!)

Again, with regard to the assertion, that the amount of mineral manure supplied in our experiments was so small in proportion to the whole bulk of soil, that it "could most certainly produce no effect, or, at the utmost, a very trifling one," we may answer—

1st, That mineral manures, applied to a similar description of soil, and in no greater proportion to its total bulk, have most marked effects upon the growth of *turnips* and our *leguminous crops*.

2ndly, That the same mineral manures, applied in the same proportion to the bulk of soil, have a distinct effect, even upon the *cereals*, *when there is an abundance of available nitrogen provided within the soil itself*.

3rdly, That salts of ammonia, and other compounds of nitrogen, applied in even less proportion to the bulk of soil, increase the produce of wheat in the particular soil in question, from that of agricultural exhaustion to that of high agricultural productiveness.

Let us now see by what kind of reasoning Baron Liebig believes that he can "convey to the reader the full conviction" that our own experiments not only contradict the conclusions "that the mineral constituents of wheat cannot *by themselves* increase the fertility of land," and "that the produce in grain and straw is rather proportional to the supply of ammonia," but that they are also the "strictest and most satisfactory proofs" of *his own* opinions.

Those of our results which he particularly brings under criticism with this view, are—

1st, Those of the continuously unmanured plot; and,

2ndly, Those of a plot (10 *a*) which, after having had mineral manures in the first year, without yielding any practical increase of produce, had then ammonia salts only, for a series of years; by means of which, a large number of heavy crops have been obtained.

In Diagram I. we have the results of these two plots, and those also of plot 10 *b* by their side, from the commencement of the

DIAGRAM Nº 1.

<table>
<tr><th>Plots</th><th>1844</th><th>1845</th><th>1846</th><th>1847</th><th>1848</th><th>1849</th><th>1850</th><th>1851</th><th>1852</th><th>1853</th><th>1854</th><th>1855</th><th>AVERAGE 1845-55</th></tr>
<tr><td colspan="14">Total Produce (Corn and Straw) lbs.</td></tr>
<tr><td>3</td><td>2043</td><td>4153</td><td>2720</td><td>3025</td><td>2664</td><td>2843</td><td>2721</td><td>2710</td><td>2457</td><td>1772</td><td>3496</td><td>2860</td><td>2856</td></tr>
<tr><td>10ª</td><td rowspan="2">2120</td><td rowspan="2">6246</td><td>4094</td><td>4593</td><td>3701</td><td>4992</td><td>4810</td><td>5036</td><td>4107</td><td>2691</td><td>5808</td><td>3797</td><td>4534</td></tr>
<tr><td>10ᵇ</td><td>2671</td><td>4579</td><td>4530</td><td>5117</td><td>3120</td><td>4985</td><td>4162</td><td>3578</td><td>7003</td><td>5073</td><td>4642</td></tr>
<tr><td colspan="14">Total Increase (Corn and Straw) lbs.</td></tr>
<tr><td>10ª</td><td rowspan="2">77</td><td rowspan="2">2093</td><td>1374</td><td>1568</td><td>1037</td><td>2149</td><td>2089</td><td>2326</td><td>1650</td><td>919</td><td>2312</td><td>937</td><td>1678</td></tr>
<tr><td>10ᵇ</td><td>-49</td><td>1554</td><td>1866</td><td>2274</td><td>399</td><td>2275</td><td>1705</td><td>1806</td><td>3507</td><td>2213</td><td>1786</td></tr>
</table>

Explanation of Diagrams 1 & 2.

- *Unmanured.*
- *Mineral Manure only.*
- *Ammoniacal Salts only.*
- *Ammoniacal Salts and Mineral Manure.*

DIAGRAM Nº 2.

<table>
<tr><th>Plots</th><th>1850</th><th>1851</th><th>1852</th><th>1853</th><th>1854</th><th>1855</th></tr>
<tr><td colspan="7">Total Produce (Corn and Straw) lbs.</td></tr>
<tr><td>3</td><td>2721</td><td>2710</td><td>2457</td><td>1772</td><td>3496</td><td>2860</td></tr>
<tr><td>17</td><td>6053</td><td>5615</td><td>5148</td><td>2533</td><td>7923</td><td>3059</td></tr>
<tr><td>18</td><td>5775</td><td>5574</td><td>2620</td><td>4773</td><td>3915</td><td>6265</td></tr>
<tr><td colspan="7">Total Increase (Corn and Straw) lbs.</td></tr>
<tr><td>17</td><td>3332</td><td>2905</td><td>2691</td><td>761</td><td>4427</td><td>199</td></tr>
<tr><td>18</td><td>3054</td><td>2864</td><td>163</td><td>3001</td><td>419</td><td>3405</td></tr>
</table>

experiment up to the present time—that is to say, from 1844 to 1855 inclusive. And, as before, we give in this place as little detail as possible, in order that the main and more general facts may stand out the more prominently.

The plan of the diagram is as follows:—

In the top line of figures, are stated the years during which the experiments were conducted. In the second line of figures the total produce (corn and straw) per acre per annum of Plot 3; the continuously unmanured plot.

In the third line of figures, we have the produce of Plot 10*a*; which was manured in the first year with a mineral mixture, containing superphosphate of lime and silicate of potass, and in every succeeding year, with a somewhat excessive amount of ammonia salts only.

In the fourth line of figures, is given the total produce of Plot 10*b*; which in the first year had the same minerals as Plot 10*a*, and afterwards, sometimes the same amount of ammonia salts as the latter, sometimes no manure at all, sometimes a complete mineral manure in addition to the ammoniacal salts, and sometimes the mineral manure alone.

And, in the two lower lines of the diagram, we have the *increase* of total produce over that of the unmanured plot, on the Plots 10*a* and 10*b* respectively.

And in order that the comparison, both as to the general character of the manuring, and the amount of produce, on the several plots, may be brought to one convenient view, the statement of the manuring is not repeated; but only indicated by squares of *shading*, which may be supposed to represent the different plots, thus:—

Unmanured—*unshaded.*
Mineral manure—*horizontal shading.*
Ammonia salts—*perpendicular shading.*
Minerals and ammonia salts together—*dotted shading.*

Before entering upon a comparison of the results of the several plots, we must pass under review Baron Liebig's remarks on the produce of the unmanured plot; by which he not only seeks to show, that our soil was naturally so rich in available mineral constituents, as to be utterly unfit for experiment—an objection of which we have already disposed—but he also seeks to draw the conclusion, from the variable amount of produce of the unmanured plot in different years, that this was due to the variable amount of mineral constituents dissolved in the soil in the same time; and hence, he seeks to claim the greater accumulation by the plant in one year than in another of carbon and nitrogen from atmospheric sources, simply as the result of an increased supply to the plant of *soluble or available minerals.*

Thus, comparing the produce of 1844 with that of 1845, the latter being twice as great as the former, he says:—

"If in the year 1844 a certain amount of rain fell on the land, and thus a certain amount of mineral constituents was rendered available for the plant; and if, in 1845, there fell, at the favourable season, one half more rain, this obviously dissolved one half more of mineral constituents. Had these not been dissolved they could not have entered the plant and been there employed—that is to say, without their aid the crop of 1845 could not have increased by one-half.

"That to which, in these remarks, I wish particularly to direct the attention of farmers, is the fact that, in this striking case, the produce of the land in grain and straw, and therefore in nitrogenised matters, was much increased without the smallest addition of nitrogenous manure, for the land received no manure whatever; and solely from the increase in the amount of the mineral constituents, present in the soil, *dissolved in the same time*."—*Principles*, pp. 69, 70.

Here Baron Liebig maintains that the large amount of minerals dissolved by the increased fall of rain enabled the plant to appropriate the additional supply of nitrogen from atmospheric sources. We hold, on the contrary, that, owing to climatic variations, the *atmospheric supply*, either through the medium of the soil, or directly to the plants themselves, or both, was greater; *therefore* the plants were enabled to take up a larger amount of minerals from the soil. And that this was so, is, we think, susceptible of proof far more logical than the contrary supposition. Thus our experiments show,—

1st. That the varying produce of the unmanured plot by no means bore any constant and direct relation to the varying amount of rain-fall of the different seasons; that is to say, to the amount of *mineral solvent;* but that, on the contrary, it depended much more on the coincidence with a certain amount of rain-fall, of those conditions of atmosphere as to temperature and moisture, which Baron Liebig himself admits must influence the amount of fluid passing through the plant, and which are also known to imply a greater power in growing plants to assimilate atmospheric food;—even though it cannot be supposed that they effect a *greater solubility of the minerals.* Whilst, without this greater available supply of atmospheric nutriment, either to the roots or to the leaves, the necessary and abundant mineral constituents in the soil would have been utterly unavailing.

2ndly. That a *direct supply of soluble mineral constituents* yielded scarcely any increase over the unmanured plot; whilst the supply of available nitrogen—*even with one and the same set of conditions as to mineral supply, rain-fall, and temperature*, nearly doubled the amount of produce. That is to say, an increased supply of the normally atmospheric food of plants had a far greater effect in enabling the plants to take up

from the soil and assimilate an increased amount of their necessary mineral constituents, than either the direct supply of the *soluble minerals*, or an increased amount of *rain* or *mineral solvent*.

The varying produce of the unmanured plot was therefore, *not* in proportion to the amount of soluble or available *soil-proper constituents*—that is, *minerals*—which, even when existing in excess, were utterly powerless, unless, either by climatic variations or by direct nitrogenous manures, additional supplies of the normally atmospheric food of plants were at the same time provided. True, no one will doubt the assertion, that "had these constituents not been present in the soil, an increased supply of carbonic acid and ammonia from the air could not have had any effect on the crop." Such an assertion, thanks to Baron Liebig, is at the present day a simple *truism*. And, we must here again remind the unwary reader, that the question between Baron Liebig and ourselves, has never been, whether or not plants could grow without a due supply of mineral constituents, but, as we have amply shown by the copious quotations given in the earlier part of this paper, Baron Liebig's doctrine has been—and indeed many passages in his new work would indicate that it still is—that "if only the soil contain a sufficient supply of the mineral food of plants," *then* "the ammonia required for their development will be furnished by the atmosphere"; or, as he now has it, when speaking of the varying produce of our unmanured plot, "a larger quantity of these mineral substances became active in the same time, and the surface of the land was thus enabled, *by the plants growing on it*, to absorb from the air one-half more carbonic acid and ammonia than in the preceding year." We, on the other hand, maintain, not that the mineral constituents can be dispensed with, but that in the ordinary course of agriculture with rotation, they exist relatively to other constituents in abundance, and that, notwithstanding this abundance, the main saleable produce of the farm, the *cereal grains*, are utterly incompetent to yield a full agricultural crop, unless there be artificially provided, *within the soil itself*, a liberal supply of available nitrogen, normally the atmospheric food of plants. The question, then, is, not whether mineral constituents are essential to the growth of plants, nor whether the supply of them in manure will yield an increase of grain *provided there be an excess of available nitrogen within the soil*—for both of these postulates we need not say we fully assent to—but it is and has been, whether or not a liberal supply of the soluble mineral constituents of the cereals, to a soil suffering the exhaustion of an ordinary course of rotation, will enable the crop to assimilate in any practical and agriculturally adequate degree, a larger amount of nitrogen from atmospheric sources?

To this we answer in the negative. And, let us see, how Baron Liebig seeks to show, that our experiments contradict the equivalent assertions—"that the mineral constituents of wheat cannot *by themselves* increase the fertility of land," and "that the produce in grain and straw is rather proportional to the supply of ammonia."

We have before explained (see Diagram I.), that plot 10 of our experimental wheat-field was manured in 1844 with a mixture of silicate of potass and superphosphate of lime, and in every subsequent year one portion of it (10*a*) received a very liberal amount of ammonia salts only: the result being a very considerable increase of produce compared with the unmanured plot. This increase, according to Baron Liebig, is due to the—

"constituents of the soil, plus 560 lbs. of superphosphate of lime, plus 220 lbs. of soluble silicate of potass, plus 1960 lbs. of ammoniacal salts;"

And he goes on to say—

"it follows that the increase of produce was by no means the effect of the ammonia alone, as Mr. Lawes will have it, but that the active mineral constituents of the soil just mentioned have had their full share in producing this effect.

"What, then, are the circumstances in which theory leads us to anticipate such an increase of produce?

"The answer will be found in my work, p. 134."

We give the sentence as it really does occur at page 134 of the fourth edition of Baron Liebig's work, the portions between brackets, thus [ ], being omitted by Baron Liebig in his quotation (*Principles*, p. 109):—

"The cereals require the alkalies and silicates liberated by the lime, and rendered fit for assimilation by plants. If there be present decaying matter yielding to the plants carbonic acid, their development may be favoured by this means; but this is not necessary. For if we furnish to the soil ammonia, and to the cereals the phosphates essential to their growth, [*in the event of their being deficient,*] we furnish all the conditions necessary for a rich crop, [*as the atmosphere forms an inexhaustible magazine of carbonic acid,*]"

The object of this sentence in Baron Liebig's work, was simply to explain that the beneficial action of burnt lime upon soils depended upon its liberating in the soil, the "*alkalies and silicates*" which the cereals require, and that, as the amount of humus must thereby be lessened, it was obvious that, in the event of other constituents not being deficient, the plants were enabled to rely upon *the atmosphere* as an inexhaustible magazine of *carbonic acid.* Whether or not Baron Liebig's 'Theory,' as amply developed in entire chapters of the same work, as well as in other writings, is properly represented by this individual and mutilated sentence, the reader will judge for himself, from the evidence we have adduced as to what that theory really was.

But can the increase of produce of plot 10*a* over the unmanured plot be attributed to the efficacy of the mineral constituents supplied in the first year, in the sense in which Baron Liebig attributes efficacy to soluble mineral manures; namely, as increasing the assimilation of nitrogen from *atmospheric* sources?

Diagram I. shows that the minerals alone (superphosphate of lime and silicate of potass), which were employed in 1844, gave only 77 lbs. more produce than the unmanured plot.

In 1845, a liberal supply of ammonia salts alone, to this plot 10, on which soluble minerals alone had given scarcely any increase in the previous year, increased the produce over that of the unmanured plot by more than 2000 lbs.

In the third year (1846), this plot 10 was divided into two equal portions. One half (10*a*) again received ammoniacal salts alone, and the other (10*b*) no manure at all.

Now surely, if the soluble minerals supplied in the first year, are to have so much of the credit of the increase of crop during the seven years, and if, with "a sufficient supply of the mineral food of plants," . . . "the ammonia required for their development will be furnished by the atmosphere," surely, upon these suppositions, we ought to get some increase of produce over the continuously unmanured plot, on plot 10*b*, in this third year (1846); when, having had, but two years previously, this supposed very efficient supply of minerals, it is now left unmanured. The fact is, however, that in 1846 the *continuously* unmanured plot gave 2720 lbs. of total produce, and plot 10*b* only 2671 lbs.!—though 10*a*, where ammonia salts were again applied, gave 4094 lbs.! The result is, then, that plot 10*b*, with minerals in 1844, ammonia in 1845, and no manure at all in 1846, gave even rather less produce than plot 3 (the continuously unmanured plot), which had had no supply of minerals at all. How, we would ask, are these facts consistent with attributing the increased produce during the seven years on plot 10*a* "*to the one only constant value which operated*" *in the experiments*—"that is, *to the total sum of the available or soluble nutritive mineral constituents present in the soil*"? The obvious truth is, that however liberal the supply of minerals in the soil, they were utterly incompetent to yield any agriculturally adequate increase of produce of wheat, unless accompanied by an artificial supply of available nitrogen within the soil; and this being so, we would ask, Was not the produce "*rather proportional to the supply of ammonia*"?

In 1847, plots 10*a* and 10*b* both received equal amounts of ammonia-salts alone, and gave nearly identical amounts of produce, and half as much again as the unmanured plot.

In 1848, the produce of the unmanured plot was 2664 lbs.; that of 10*a*, with ammoniacal salts only, for the fourth year,

3701 lbs.; but 10*b*, with minerals and ammonia, gave 4530 lbs. Here, then, *after growing wheat successively year after year by means of very large amounts of ammonia-salts, upon land previously exhausted by a heavy course of cropping*, we find a distinct effect from the admixture of minerals with a further dressing of ammonia. But is this action of minerals in rendering efficient an excessive supply of ammonia in the soil, after such a course of mineral exhaustion as never happens in the ordinary course of farming with rotation—is this the action still insisted upon by Baron Liebig, namely, that of enabling the surface of the land, "*by the plants growing on it*, to absorb from the air" a larger amount of carbonic acid and ammonia?

In 1849, both plots (10*a* and 10*b*) were again supplied with equal quantities of ammonia-salts alone, and both gave more than 2000 lbs. increase over the unmanured plot; whilst 10*b*, with its liberal supply of minerals the year before, only gave 125 lbs. more than 10*a*.

In 1850, ammonia salts alone on 10*a* again gave more than 2000 lbs. of increase; but 10*b*, to which minerals were added—this time *without ammonia*—gave only 399 lbs. of additional produce, this slight amount being chiefly due to a small residue of ammonia remaining in the soil from the high ammoniacal manuring of the previous years.

That the minerals employed in 10*b*, though yielding only 399 lbs. of increase, still practically exhausted the soil of its immediately available supplied ammonia, is obvious from the results of the next two years (1851-2). Thus, with a large and equal supply of ammonia-salts only to both plots (10*a* and 10*b*) in these two years, we have almost identically the same amount of produce on the former as on the latter; although 10*b* had not only twice received a liberal supply of minerals, which had been withheld from 10*a*, but had also given a less gross total produce, reckoning from the commencement of the experiment.

From this time—although the continued application of ammonia-salts only on 10*a* gave in the ninth year an increase of 919 lbs.; in the tenth, of 2312 lbs.; and in the eleventh, of 937 lbs. of corn and straw—the employment (on 10*b*) of minerals, in addition to the excessive amount of ammonia, produced a still further increase.

What, then, is the general result of these experiments? Excluding the first year, in which the plots 10*a* and 10*b* both received mineral manure without yielding any practical amount of increase, it is as follows:—On the average of eleven years of the continuous growth of wheat, the unmanured plot gave a total annual produce (corn and straw) of 2856 lbs.; plot 10*a*, with eleven years of ammoniacal salts alone, gave 4534 lbs., being

an *increase* over the unmanured plot of 1678 lbs; and plot 10*b*, with nine years of ammoniacal salts and two years of minerals, gave an annual average of 4642 lbs. of total produce, and of 1786 lbs. of *increase*. That is to say, plot 10*b* has only given during these eleven years, an annual increase of 108 lbs. more total produce than plot 10*a*, although during this period it received considerably more than ten times as much of all the more important mineral constituents, except silica, as would be contained in the total increase in the eleven years, of 10*b* over 10*a*! In fact, all that this mineral supply has done, has been to render efficient that amount of ammonia, which was added in *excess* of the annually available supply of minerals from the soil itself.

But in Diagram II. (p. 439), we have even a more striking answer still, to the assertion that in our experiments the whole produce is proportional "*to the total sum of the available or soluble nutritive mineral constituents present in the soil.*" The produce of two plots (17 and 18) is here compared with that of the continuously unmanured plot. The results extend over a period of six years, namely, 1850 to 1855 inclusive. As before, the unmanured space is without shading; mineral manures are represented by *horizontal* shading, ammonia-salts only by *perpendicular* shading, and the mixture of both minerals and ammonia by *dotted* shading.

It should be mentioned, that the plots (17 and 18) had, previously to 1850, been manured somewhat similarly since the commencement of the experiment in 1844. They had generally received a liberal supply of minerals and of nitrogenous matter also; plot 17 having had upon the whole rather more nitrogen supplied to it than plot 18.

In 1850, both plots (17 and 18) received a large amount both of soluble minerals and of ammonia-salts, and they each gave nearly a ton and a half more produce than the unmanured plot; though plot 17, which had been rather the most highly manured throughout the previous years, gave rather more produce than plot 18.

In 1851, plot 17 received the same amount of minerals and ammonia as previously, and gave 2905 lbs. of increased produce. Plot 18 received no minerals, but the same amount of ammonia as plot 17, and the result is nearly as much increase, that is, 2864 lbs. instead of 2905 lbs.

In 1852, plot 17, which had minerals and ammonia the year before, has now only ammonia; and plot 18, which had ammonia only in the previous year, has now only minerals. The result is, that the ammonia plot (17) gives 5418 lbs. of produce,

or 2691 lbs. of increase; whilst the mineral plot (18) gives only 2620 lbs. total produce = only 163 lbs. increase.

In 1853, the plot which had previously ammonia only, has now only minerals; and the one which had minerals only, has now only ammonia. And we have again with the ammonia 4773 lbs. of produce = 3001 lbs. increase; and with the minerals only 2533 lbs. of produce = 761 lbs. of increase.

In 1854, the manures are again transposed; and this being a very favourable season, we have, with the ammonia, 7923 lbs. of produce = 4427 lbs. of increase, or nearly 2 tons; and with the minerals only, 3915 lbs. of produce = 419 lbs. of increase, or *more than* 4000 *lbs. per acre less increase than with the ammonia salts.*

Lastly, in 1855, the manures being again transposed, so also is the relation of produce on the two plots—the ammonia plot giving 6265 lbs. of produce = 3405 lbs. of increase; and the mineral plot only 3059 lbs. of produce =199 lbs. of increase.

Tracing the history of each plot separately, the *increase over the unmanured plot* is as follows:—Plot 17, with minerals and ammonia, in 1850, 3332 lbs.; with the same in 1851, 2905 lbs.; with ammonia only in 1852, 2691 lbs.; with minerals only in 1853, 761 lbs.; with ammonia only in 1854, 4427 lbs.; and with minerals only in 1855, 199 lbs. Plot 18 again, with minerals and ammonia in the first year, gives 3054 lbs.; with ammonia only in the second year, 2864 lbs.; with minerals only in the third year, 163 lbs.; with ammonia only in the fourth year, 3001 lbs.; with minerals only in the fifth year, 419 lbs.; and with ammonia only in the sixth year, 3405 lbs. of increase, in each case, over the unmanured plot.

We ask then, do these results either contradict the assertions, "that the mineral constituents of wheat cannot *by themselves* increase the fertility of land," and "that the produce, in grain and straw, is *rather proportional to the supply of ammonia*"?—or do they "*prove*" what we "intended to *disprove*," namely, that the whole produce is proportional "to the total sum of the *available or soluble nutritive mineral constituents present in the soil*"?

What the "*Mineral Theory*" of Baron Liebig, as developed in his previous writings, really was—how that "theory" was understood by others as well as ourselves—and how independent, according to it, our cultivated plants should be of available nitrogen supplied to the soil, if only they are liberally provided with their necessary mineral constituents—the reader is by this time fully aware. He has also seen, that in passages and arguments in Baron Liebig's recently-published '*Principles*,' this identical "Mineral Theory" is still main-

tained; and also, how strenuously he has endeavoured to show, that the increase of produce in our experiments was due, not to the efficacy of the ammoniacal salts employed, but "to the total sum of the available or soluble nutritive mineral constituents present in the soil." But now for the other side of the question.

Besides stating, as already pointed out (and in spite of his lengthened argument and summing up to the contrary), that the increase we obtained by manuring with ammoniacal salts alone, was only what theory plainly predicted, he says:—

"When we remember that it is the object of scientific research to discover the cause of the efficacy of ammoniacal salts, we must not forget, in our inquiries, *that the increase of produce, obtained by the use of these salts, is to be regarded in itself as a firmly established fact*, which can in no way be affected by the views we may entertain as to its cause."—*Principles*, p. 98.

The efficacy of ammoniacal salts in yielding an increase of produce, not only in our own experiments, but as a "firmly-established fact," is now then fully admitted. And as it was impossible, in the face not only of our own particular experiments, but of now generally recorded experience, to avoid this admission in some form, how is it that Baron Liebig brings this result into consistency with the theory which supposes the increase to be proportional to the soluble *minerals* present in the soil? We could blush for Baron Liebig as we quote his words:—

"In these experiments, three portions of land were each manured, for seven years, with *mineral manure* (mineral constituents of the soil *and ammoniacal salts*). . . . ."

And again, in the same page—

"It follows from this, that *farm-yard or stable manure can be replaced in its entire effect by mineral manure*; and not only replaced, for it can be, by the use of *mineral substances alone* (*sulphate of ammonia and sal-ammoniac are mineral*), surpassed in its fullest efficacy."—*Principles*, p. 90.

Thus then "ammoniacal-salts," "sulphate of ammonia, and sal-ammoniac," are to be classed as *mineral manures!* This is indeed begging the whole question! But a manœuvre so transparent as this, would not even require notice, were it only addressed to the scientific reader. As it is, however, it is necessary to remind the uninitiated or unwary, that throughout the discussions on the subject of agricultural chemistry during the last ten or a dozen years, the term "*mineral manure*" has acquired an entirely technical significance, and that it has been employed to designate those constituents which, when assimilated by the plant, would remain as *ash* after its incineration; and it has been used, emphatically to distinguish such constituents of plants or manures, from the combustible or volatile portions—that is, from the nitrogenous or ammoniacal, the carbonaceous, &c. Indeed, we need not go far to establish, from the words of Baron Liebig himself, the re-

cognised distinction, in agricultural discussions, between the terms *mineral*, and *ammonia* or *ammoniacal*. Thus he says :

"The *mineral* constituents act, as is shown by the produce of the unmanured land, without any artificial supply of *ammonia*."

"The *ammonia* increases the produce only if the *mineral* constituents be present in the soil in due quantity and in an available form."

"*Ammonia* is without effect if the *mineral* constituents are wanting. Consequently, the action of *ammonia* is limited to the acceleration of the action of the *mineral* constituents in a given time."—*Principles*, p. 86-7.

". . . The other is the action of *sulphate of ammonia* as a solvent for certain important *mineral* constituents of the soil."—*Ib.*, p. 99.

"*Ammonia*, when used as a manure alone, and when there is a want of *mineral* constituents in the soil, is like the spirits which the labourer takes, in order to increase his available labour, power, or imagination."—*Ib.*, p. 106.

It is needless to multiply quotations. The *ruse*, however, has not been entirely without success. For in public discussion of the subject at the late Meeting of the British Association, before Baron Liebig himself, one of his advocates stated, that the difference between Baron Liebig and ourselves rested mainly on a misunderstanding—on a different use of nomenclature—for "*salts of ammonia are mineral manures*"! This method of begging the whole question was, however, we were glad to find, entirely disallowed by mutual friends of Baron Liebig and ourselves with whom we conversed on the subject; and we are glad to find, that writers of the agricultural press have also expressed their sense of this manœuvre. Thus, in an able article on this discussion in the 'North British Agriculturist' (Nov. 7, 1855), the writer says—"Neither can we think him justified in claiming *sulphate of ammonia and sal-ammoniac* as *mineral* substances ('Principles,' p. 90), which is simply *begging the whole question at issue.*"

But Baron Liebig has yet another way of claiming the necessarily admitted action of ammoniacal salts, as one of *minerals*. Thus he says :—

"Now, since sulphate of ammonia and sal-ammoniac, in the same way as carbonic acid, increase the solvent power of water for these essential ingredients of the food of plants, the question at once arises, whether their good effects may not depend in great part on *this* property, and whether, in the experiments of Mr. Lawes, the whole effect of the ammoniacal salts do not consist of two actions, namely, that of ammonia, as food for plants, as a source of nitrogen, and that of its salts as replacing carbonic acid? The answer to this question may serve to reduce to its real value the assertion of Mr. Lawes (vol. xii. p. 24), 'that it would be much nearer the truth to say that the crop has risen and fallen in proportion to the diminution or increase of the ammonia supplied to it in manure.'"—*Principles*, p. 91-2.

"But if, on the contrary, only a small part of the ammonia acted by its nutritive property, and by far the greater part by its solvent power for *phosphates* and *silicates*, its action is explained in a more satisfactory manner; for in this case the effect is proportional to the quantity of water which entered the plants, and was given off by evaporation from their surface, the solvent

power of this water for these substances having been increased by the ammoniacal salts. The effect of the *earthy phosphates* and of the *soluble silicates* depends on the quantity of them in the soil; their effect in a given time is proportional to the quantity which enters the plant in that time. This again is proportional to the degree of their solubility in rain-water, and to the amount of rain-water absorbed by the plant."

"Both properties—that of ammonia as a *nutritive agent*, or source of nitrogen, and that of the ammoniacal salts as *solvents*—have certainly co-operated to give the increased produce; for since the total produce, 28,431 lbs. of grain and straw, of the lot manured with ammoniacal salts, was to that of the unmanured land, 18,122 lbs. grain and straw, as three to two, and consequently the excess of the former was equal to half the amount of the latter, it is evident that this excess must have contained exactly as much silicate of potass and phosphates as existed in one-half the crop of the unmanured land. Now, since ammonia cannot replace these essential constituents of the wheat-plant, it follows, that, by the agency of the ammoniacal salts, this entire additional quantity of mineral constituents was rendered soluble and available for the plant. These salts have enabled the rain-water, in equal volume, to dissolve and carry into the plant, in the same time, one-half more of these substances than was yielded, without ammoniacal salts, by the unmanured land."—*Ib.*, pp. 99-101.

We are here told, then—in *March*, 1855—that the efficacy of the salts of ammonia in our experiments is to be attributed in a great measure to their *solvent action* on the *phosphates* and *silicates* of the soil; the increase of produce being greatly due to the consequently increased supply of these minerals to the plant. The reader will imagine therefore our astonishment, when, in *September of the same year*, we heard Baron Liebig in the public discussion of our experiments, energetically maintain, that the presence in the soil of ammonia and its salts must *reduce* the solubility of the silicates! We have since found, that he had then already published two papers in Germany, in the course of which he sought to establish the latter view. We are not disposed to dispute the probable truth of this amended conclusion. For, in experiments instituted with the view of testing the probability of Baron Liebig's previous assumption, we had found that water containing *salts of ammonia*, when percolated through a given bulk of soil, *dissolved less silica* than pure water so percolated. At the same time, however, we must say, that we cannot admit the legitimacy of deductions from experiments made upon *pure silicates out of the soil*, as to what would happen under the complicated and little understood chemical conditions of *cultivated soils*.

At any rate, however, we must conclude, that Baron Liebig's explanation of the efficacy of ammonia-salts in our experiments, so far as it supposed an increased supply to the plant of *silica*—the characteristic mineral constituent of the crops to which ammonia as a manure is peculiarly adapted—is now abandoned!

But what of the phosphates? We will neither assert nor deny,

that these important mineral constituents may be rendered more soluble in the soil, in a given amount of water, provided this water contain ammoniacal salts. But, whether or not the increase in the produce of grain and straw in our experiments, was in any important degree due to this cause, is quite another question. Upon this point some opinion may be formed from the following considerations:—

How is it, we would ask—if, in the experiments where ammonia-salts alone were employed for a series of years, "only a small part of the ammonia acted by its nutritive property, and by far the greater part by its solvent power for phosphates"—how is it, we would ask, if this were the case, that the addition of a very much larger *direct supply of phosphates* than the increase of crop could require, indeed in an amount and in such a form of easy solubility as to yield extraordinary results with some other crops than the cereals, should, with the latter, when used without ammonia, give scarcely any increase whatever? In other words, are we to suppose a greater amount of phosphates to be rendered soluble from the stores of the soil itself, by the solvent action of the ammonia-salts employed, than by the *direct use*, in an *easily soluble form*, of many times more phosphates than the increase of crop could require? On this point we may state, that the increase of produce on plot 10*a* contained an annual average of 6 to 7 lbs. of phosphoric acid; whilst ten times that amount was the general dose of that acid supplied to the soil in our experiments when mineral manures were employed—a large part of it existing, when added to the soil, in that form of easy solubility as superphosphate of lime, which is found so efficient for other crops than the cereals, the remainder existing as very finely powdered earthy phosphate.

Would it not be both more candid and more consistent, instead of thus wrestling to the last to maintain the shadow of an obviously half-abandoned theory, to attribute the increased assimilation of minerals on a given space of ground, which is necessarily incident to an increase of crop, rather to a multiplication of the feeders of the plants, and an increased vigour of growth under the influence of nitrogenous supply, which, by virtue of the larger amount of soil-solution which must be absorbed, enables them to take up with it more of those minerals which were obviously neither wanting nor insoluble; although they cannot be assimilated by the cereals beyond a limited amount (varying with atmospheric supplies), unless *nitrogen in an available form* be at the same time provided *within the soil itself?*

We proceed next to show how, the effects of available nitrogen supplied to the soil being necessarily admitted, the fact of its being thereby enabled to yield an increase of produce, is not to

be considered as an increase of fertility; and the farmer is therefore to be cautious how he adopts any such ruinous means of raising the produce of his land. Baron Liebig says :—

"In that work of mine I have fully explained that the idea of fertility in a soil, essentially comprises that of the *continuance and duration* of the crops. No one regards as fertile land such as, without manure, bears good crops for a year or two, and no more. In this point of view, the fertility of a soil is in direct proportion to the conditions of fertility present in it; that is, to the *mineral substances* which are necessary for the nutrition of plants."—*Principles*, p. 75-6.

"If we manure the same land with 3 cwt. of ammoniacal salts, we shall have, in one year, a crop one half heavier than on the unmanured land; we shall obtain annually one-and-half crops, or, in eight years, the produce of twelve average crops. That is to say, the soil will have lost, in eight years, as much mineral matter as it would have lost in twelve years without ammoniacal salts; it will therefore be exhausted, or become unfruitful for wheat, four years sooner than if no ammoniacal salts had been used.

"I hold, therefore, that which in my work I have endeavoured so fully and minutely to explain, that, in reference to the exhaustion of the soil, *ammonia* or *ammoniacal salts, used alone*, are the kinds of manure which impoverish a soil, or in other words, consume the capital of the land, the most rapidly.

"In one case only does the fertility of the soil manured with ammonia, or its salts, maintain itself, namely, when these are accompanied by the mineral substances which are annually removed in the crops. These may be restored either by annually adding as much as is removed, or by adding after the fifth crop a five-fold quantity of them. If this be once omitted, the effect must become perceptible in a series of years.

"The rational agriculturist must not believe, that he can remove from a rich fertile soil, without any compensation whatever, a part of its constituents, and not, by so doing, sooner or later impair its fertility; for this fertility, or the produce in a given time, is the effect of the whole sum of the actions of all its constituents; not only of that portion of them, which has entered the plants, but also of the rest of the available supply, which is left in the soil. The entire supply, or sum, has produced this result, namely, that the roots found everywhere their necessary food; and if we remove a part of the whole supply of these constituents, then the roots will no longer find their proper food in that part of the soil where they are wanting.

"Let us only suppose that during the last few centuries our ancestors had acted on the principles here laid down, in their full extent and strictness; what a paradise of fertility would England be at this day!"—*Ib.*, p. 81-3.

We must here first notice the running insinuation in these passages, that we would recommend as a practice for adoption in agriculture generally, the continuous growth of corn by means of nitrogenous manures, without any other return to the land. It is only to those who have never read our Papers, that it is necessary to say, that a more incorrect impression of our views could not possibly be given than that which is herein implied; and which is more plainly, if not more courteously, expressed in the following sentence :—

"It is not easy to understand how Mr. Lawes could deduce from his results the conclusion '*that nitrogenised manures are peculiarly adapted for the cul-*

ture of wheat,' since such manures can only produce a favourable result if certain *preliminary conditions, which Mr. Lawes has entirely disregarded,* be fulfilled. There could hardly be made an assertion better calculated to mislead the practical farmer."—*Ib.*, p. 79.

To meet these gratuitous statements from such a quarter, it is necessary to repeat, then, that the whole of our recommendations to the farmer in this matter, have been repeatedly and elaborately defined, to apply to agriculture as generally practised in this country, that is to say, agriculture *as it is*—the "preliminary conditions" which we have supposed being, a *cultivated soil*, and a *rotation of crops*. And what, then, does a rotation of crops in this country involve? It involves the growth of root and other fallow crops; the growth of these involves the feeding of animals on the farm; the feeding of animals on the farm involves the production of home manure; and the production of home manure involves the "*preliminary condition*", of a periodical return from the resources *within the farm itself*, of a large proportion of the mineral constituents which have been removed from the land in the crops. Into all this we have gone with considerable detail, again, and again;—as well on the assumption of there being, as of there not being, a certain amount of imported constituents to be further taken into the calculation. With this explanation we will again apply to Baron Liebig his own words: "It is not difficult to refute the opinions of another if we ascribe to him assertions which he has never made."!

But now for the assertion that *fertility* is almost exclusively referable to the *mineral* richness of the soil. True, there can be no fertility *without* a liberal provision of minerals; but what, we would ask, is the use to the practical farmer of maintaining his land in a condition of so-called "*fertility*," which, *without the addition of something else*, will yield him no increase of produce whatever? What, we would ask, is the use to the farmer, of a merely *latent* or *reserved* capability of production, if this latent capability be not brought out into *activity* and *use?* And it is undoubtedly true, that in agriculture generally, with rotation, there is a considerable accumulation of this latent or reserved capability of production, which cannot be brought into activity and use for the increased growth of the main saleable products of the farm—the cereal grains—without the accumulation, *within the soil itself*, of *available nitrogen*. Again, experience shows, that by the production of grain, the stores of *available nitrogen within the soil* are far sooner exhausted or brought down to an annual *minimum*, than those of the minerals. How much more strongly, then, to be consistent, should the argument be applied against the exhaustion of the land of its *available nitrogen!* And should not Baron Liebig, in obedience to his own principle of *non-*

exhaustion, precisely reverse the advocacy reiterated in the following sentence?—

"I had myself, in the first edition of my work, attributed to *ammonia* a *preponderating* value and importance; *and I thought I had sufficiently corrected this error in the subsequent editions.*"—*Principles*, p. 79.

Surely, if any of the constituents necessary to the production of our crops, should have, in the eye of the *agricultural chemist*, "a *preponderating* value and importance," it should be those which are the *most* easily, not those which are the *least* easily, exhausted in the course of practice!—those by the want of which the limit to our production of corn is in practice fixed—not those which, in the same course of practice, are ready and waiting, but inactive, dormant, and unremunerative, because unassociated with others which we are told should nevertheless not have attributed to them, "a *preponderating* value and importance"!

But we have not yet done with the limitations to a free and unqualified admission of the pre-eminent importance in agriculture, of an accumulation of *nitrogen in an available form within the soil itself*:—

"The advantage of this artificial supply of ammonia, as a source of nitrogen, *is limited*, like that derived from the presence of humus in the soil, to a *gain of time*."—*Ib.*, p. 74.

What, we would ask, is *gain of time* in the growth of plants, but the very essence of the distinction between *natural* growth and *artificial* growth, that is, AGRICULTURE? In this admission, therefore, is involved the fullest and most convincing proof, that if any of the constituents of plants should have attributed to them "a *preponderating* value and importance," it should be those to which is due a *gain of time*.

To resume: The following is a brief summary of the criticisms to which our experiments on the growth of wheat have been submitted by Baron Liebig, with the view of showing that their results are at once consistent with his own peculiar doctrines, and inconsistent with our own conclusions.

He maintains alternately, that the supply of ammoniacal salts has *not*, and *has*, been the source of the increase! And, when it became impossible to avoid the latter conclusion, how does he qualify the unpalatable admission?

Such a result is precisely in accordance with what theory teaches!

Salts of ammonia are themselves to be included as mineral manures!

Their action is mainly that of rendering soluble the minerals of the soil, and hence it is the minerals to which at last the increase is due!

If ammonia-salts do give increase, they but exhaust the land!
Their action is only a gain of time!

And lastly, *their observed effect in our own experiments is only exceptional*, so that no deductions whatever can be formed therefrom, in regard to corn-exhaustion in any other case!

The point which we propose next to illustrate, by reference to a very condensed tabular statement of a large number of experiments is, that the provision of *available nitrogen within the soil*, has a very marked effect upon the increased growth of *barley* also—the second in importance of the cereal grains in our own country and climate.

In Table II., given below, we have the results of experiments on the growth of barley in the year 1854, in two separate fields of widely differing previous history. The portion of "*Barn-field*," the produce of which is given in the upper part of the Table, had grown turnips experimentally for ten successive years, without being manured with any nitrogenous or carbonaceous substance. It had, however, been exceedingly liberally supplied every year, with various mineral manures; which in some cases included in very large excess every constituent which the ashes of the crop would contain. The condition of these plots, indeed, would be that of such exhaustion of organic substance, and, on the other hand, of such a repletion of mineral constituents, as could not occur in the ordinary course of farming. Strange to say, however—that is, for the credit of the "*mineral theory*"—this exceedingly mineral-enriched, and nitrogen-impoverished land, gave for the season in question an excessively meagre crop. In fact, its total produce (corn and straw) was only two-thirds that of our continuously unmanured wheat-plot, and little more than half as much as that grown without manure or by mineral manure alone, in our other experimental barley-field; although the crop in the latter, some of the results of which are also given in the Table, was the fourth of barley, and the third without nitrogenous manure. Previous to the first experimental crop, however, the latter field had not been submitted to more than an ordinary course of exhaustive cropping. We have here, then, a remarkable instance of the utter incapability of a very liberal supply of mineral constituents, on a soil exhausted of organic food, to enable the plant to obtain sufficient nitrogen from atmospheric sources, for the growth of the barley-crop in adequate agricultural quantity. Nor was there in this "*Barn-field*" a difference of more than a bushel or two, between the produce of those plots which had previously received large amounts of alkalies as well as phosphates, and those which had only been manured with the latter.

TABLE II.—*Summary* of Experiments on the Growth of Barley. Average Total Produce (Corn and Straw) per acre, in lbs.

General Condition of Manuring.	Total Produce.	Total Increase by Nitrogen.
Barn-field—Harvest 1854.		
	lbs.	lbs.
Mineral Series (mean)	2474	..
Ditto (ditto) with Ammonia-salts	7382	4908
Ditto (ditto) with Nitrate of Soda	8005	5531
Hoos-field—Harvest 1854.		
Mineral Series (mean)	4656	..
Ditto (ditto) with Ammonia-salts	8127	3471
Ditto (ditto) with Rape-cake	8150	3494
Nitrate of Soda (second year without Minerals) ..	7400	2744

In this Table it is seen that the mean total produce (corn and straw together) of barley in "*Barn-field*," on the previously mineral-manured plots, is 2474 lbs.; that on land in similar previous condition, but with ammonia-salts now added, is 7382 lbs.; and that with nitrate of soda instead of ammonia-salts, is 8005 lbs.

In "*Hoos-field*" again, the mean total produce of the series manured annually with *direct* mineral manures, is 4656 lbs.; that with ammonia salts in addition, is 8127 lbs.; that with (besides the minerals) rape-cake, equal in its amount of nitrogen to the ammonia-salts of the previous series, is 8150 lbs.; and that with nitrate of soda, this being the second year of its application without mineral manure, is 7400 lbs.

Here then, in both fields, we have an enormous increase of produce in the barley crop, by means of available nitrogen supplied to the soil. And although, owing to the more limited range of the underground feeders of the barley plant, and to the much shorter period of time during which it collects its mineral food, *direct* mineral manures have a more beneficial influence upon that crop than upon wheat, yet it is obvious, that as with the wheat crop so also with barley, a maximum agricultural produce cannot be obtained, however liberal the supply of minerals, unless there be, at the same time, an accumulation of available nitrogen *within the soil itself.*

We now turn to a consideration of Baron Liebig's treatment of our recorded experiments and conclusions in reference to the growth of *turnips.* He says:—

"It seems to me worth while to consider here one more of those unmeaning practical experiences, made by one who is, according to Mr. Pusey, the first

agricultural authority in England, namely, by Mr. Lawes. It refers to the growth of turnips. (Vol. xii. p. 34, and vol. viii. part 2, p. 26, *et seq.*)"—*Principles*, p. 123-4.

[In consequence of the great length of this Paper, we must content ourselves on this occasion with examining only one or two of Baron Liebig's criticisms on this point, in that detail which we had intended.]

Baron Liebig attributes to us the assertion, that "phosphoric acid alone was found efficacious" in our experiments—a statement in direct contradiction to opinions strongly insisted upon throughout our Paper on turnip culture, from which in part he quotes. He considers the results obtained by large quantities of burnt bones and sulphuric acid, as demonstrating "the existence of a very unusual quality of soil"; and having thus admitted the fact itself, he adds :—

"But if we inquire into the reason why the credit of this striking result is given to the phosphoric acid, we find that this is a *sheer fancy*. Were any one to assert that, under the circumstances, it was the free sulphuric acid which produced the result, it would be difficult to disprove the assertion, as will be seen from the following calculation."—*Principles*, p. 125.

He then goes on to assume, that we employed in the experiment in question, "as a minimum," 400 lbs. of burnt bones (and sulphuric acid besides), every year, during eight successive years—or in all, 3200 lbs. of burnt bones; more than enough, as he tells us, for fifty average crops of turnips. Now it so happens, that 3200 lbs. of burnt bones *is* a pure assumption of Baron Liebig's, as indeed he admits in a note; but he does not the less on this account make liberal use of this assumed fact. The quantity of phosphate of lime used in the eight years was in reality more than a thousand pounds less than was supposed by Baron Liebig. Further on, after having pointed out the excess of phosphate added in the previous years, he says :—

"It is impossible to believe that the effect, in the seventh year, under these circumstances, can have depended on the newly-added phosphoric acid, as Mr. Lawes concludes."—*Ib.*, p. 126.

And again—

"What conclusion would Mr. Lawes have come to, had he manured his land, for two years, only with phosphate of lime, and had added, in the six succeeding years, 400 lbs. of sulphuric acid alone, and had he thus obtained the same produce, in eight years as if he had used 3200 lbs. of burnt bones?"—*Ib.*, p. 129.

Now it does so happen, that we have an experiment that will show, as far as such a point is susceptible of proof, that there *was* an action due to the large amount of phosphate of lime added to the soil, which could not be attributed to "free sulphuric acid" in admixture with it; and further, that a still greater excess of superphosphate of lime gave a further increment

of increase. In the following Table (III.), we have the result of this experiment; namely, that on plot 21, which, with those on plots 7 and 22, given on either side of it, will illustrate the point in question:—

TABLE III.—Selection of Results of Experiments on Turnips.
Produce of Bulb per Acre.

	Years.	PLOT 7. ¼ Cwt. Sulphate Ammonia, in 1843. 3 Cwts. ground Apatite, in 1844. 12 Cwts. Gypsum, in 1845. — Afterwards Unmanured.		PLOT 21. Superphosphate of Lime, in 1843-4-5. — Afterwards Unmanured.		PLOT 22. Superphosphate of Lime, *every Year.*	
		Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.
Norfolk Whites.	1843	6	18½	11	14¾	12	3½
	1844	3	1	7	3¼	7	14¾
	1845	5	13¾	13	2¾	12	13¾
	1846	..		1	5¼	1	18
	1847	2	11½	3	17	5	11
	1848	1	0½	6	7¼	10	11
Swedes.	1849	0	2½	0	15¾	3	15
	1850	4	6¾	8	0	11	9
	1851	3	10	6	7½	10	16¼
	1852	1	4	2	15½	8	9½
Totals ..		28	8½	61	9	85	1¾
Means ..		3	3⅕	6	3	8	10⅕

Plot 21 received in all, during the first three years of the experiment, about 800 lbs. of bone-earth, or its equivalent in apatite (mixed with sulphuric acid); and from that time it was unmanured. And since the whole produce of the ten years would only remove from the land, say one-third, of the phosphoric acid added in the first three years, it is obvious that there must have remained in the soil a large residue of the supplied phosphate, for the seven crops grown since the application of the manure.

Plot 22 had also large amounts of superphosphate of lime supplied to it during the first three years; and after that time it received every year 160 lbs. burnt bones, mixed with 120 lbs. of sulphuric acid of sp. gr. 1·7.

Plot 7, having had a small quantity of ammonia-salts in 1843, 3 cwts. of apatite in 1844, and 12 cwts. of gypsum in 1845, yielded, in 1846, without manure of any kind, so small a crop as not to be worth weighing; and this plot 7 was afterwards continuously unmanured.

It is seen that, during the first three years of the experiment, plots 21 and 22, being both manured liberally with superphos-

phate of lime, gave nearly equal amounts of produce; though plot 22, having rather the most of the manure, gave also rather a higher average produce.

In 1846, the now unmanured plot 7 (which, however, had received a large quantity of powdered apatite two years previously) yielded next to nothing; plot 21, now unmanured, but having a larger residue of phosphate of lime in the soil, and in a more easily soluble form than plot 7, gave 1¼ tons of bulb; and plot 22, with its large residue of phosphate of lime, as well as annual additional supply of superphosphate of lime, gave nearly 2 tons.

In 1847, plot 7 gave rather more than 2½ tons; plot 21, with its residue of phosphate of lime, gave nearly 4 tons; and plot 22, with its *additional supply* of superphosphate, as well as residue, gave rather more than 5½ tons.

In 1848, the comparatively non-residue plot (7) gave 1 ton of turnips; the residue-plot, 6⅓ tons; and the residue, with additional supply, more than 10½ tons.

In like manner, to the end of the experiment, it is seen that the residue-plot 21 always gives a considerable increase (varying according to season) over the comparatively non-residue plot 7; and again, plot 22, with both its accumulating residue and its additional supply, in every case gives a considerable increase over the residue-plot 21, although the latter, even up to the last year of the experiment, still retained a large proportion of the previously added phosphate, besides all that must have been available, during the ten years, from the stores of the soil itself.

Now it is quite certain, that on plot 7 there was much more phosphate supplied in the apatite in 1844, and derivable from the annually available stores of the soil, than was necessary to supply with phosphoric acid a much larger produce than was obtained on that plot. It is also quite certain, that the much larger produce on plot 21 than on plot 7 must have been due to the residue of the manuring of the years 1843-4-5. If any one, therefore, were to assert that, under the circumstances of this plot 21, "it was the free sulphuric acid which produced the result," it would certainly *not* "be difficult to disprove the assertion." And again, it is certainly also true, that the further increase obtained on plot 22 over plot 21 must be due to the additional mixture of phosphate of lime, mixed with sulphuric acid, which was annually supplied to it. And, as we have seen that on plot 21, a supply of phosphate far in excess of that contained in the crop produced—the action of which could *not* be attributed to *free sulphuric acid—did* give an increase, and as we well know that any free sulphuric acid which might reach the soil would in a very short time be neutralized, the reader will

judge for himself, whether on plot 22, the increased produce obtained was more probably due to free sulphuric acid, or to the still greater excess of phosphoric acid or its compounds supplied in the manure;—that is to say, whether the increased produce on plot 22 was not due to an action very similar in kind to, but differing in degree from, that on plot 21?

Again, Baron Liebig says,—

"If we continue our examination, we shall find, still in his own experiments, much more convincing proofs that the excess of phosphoric acid cannot have been the cause of the increased produce."—*Principles*, p. 126.

He then goes on to institute comparisons which, taking the figures simply as they stand, and without the explanations of the very results in question given in our papers, were certainly well calculated for his purpose, if the only object he had in view were to mystify, misrepresent, and fix contradiction upon agricultural phenomena. Thus, following up the incorrect assertion that "phosphoric acid alone was found efficacious" in our experiments, by assuming that we should measure the action of farm-yard manure or rape-cake, by the quantity of phosphoric acid or phosphate of lime they contained, he goes on to compare the produce by these manures, sometimes in the same year, and sometimes not, with that by superphosphate of lime alone; and then he says, in regard to these results, "in what incomprehensible contradiction do they stand to the opinions of Mr. Lawes!" One quotation alone from our paper, to which, indeed, but for the length of this article, we had intended to add many more, will show not only whether we maintained that *phosphoric acid alone was efficacious*, but whether or not it was to the phosphoric acid they contained, that we supposed the action of farm-yard manure and rape-cake was chiefly or only due.* Thus we say, speaking of superphosphate of lime,—

* As a further instance of the spirit and fairness of Baron Liebig's criticisms, he speaks of the "unpardonable blunder" of using rape-cake as a carbonaceous manure,—because, as he says, it contains a large amount of nitrogen also; on which point he quotes the analyses of Mr. Way. Those who have not read our Papers, would scarcely think it possible, that we have again and again spoken in them of the amount of nitrogen in rape-cake; and frequently also, particularly contrasted the effects of rape-cake and other organic manures, with that of ammonia-salts, in order to eliminate the action of the nitrogenous and carbonaceous supply respectively. But, Baron Liebig equally ridicules us, for using experimentally, *rice* and *oil;* substances chosen as containing little or no nitrogen. One of the carbonaceous manures by which he obtained his results, was sawdust. His anxiety to ignore that we attribute an action to carbonaceous manures, and to ridicule all our experiments connected with such manures, is however perfectly intelligible, when it is borne in mind, that he claims to have embodied in his '14th Proposition,' a *correction* and *enlargement* of his views. That Proposition is, he says, the only one of the 50 given in his '*Principles*,' the substance of which is not to be found in his previous works; and the object of that Proposition is to claim an action of animal and vegetable manures, by virtue of the *organic substance* they contain. We shall however have occasion to show, in one striking instance at

"The latter manure is the form which is found to produce the greatest effect upon the young plant, and especially upon the development of a large amount of fibrous roots. . . . . *It must, however, be clearly understood that the bulk of an agricultural crop of turnips depends materially upon the amount of organic matter contained in the soil, without which the development of the power of growth by means of the phosphate will be unavailing.* . . . . *Rape-cake, as containing a large amount of organic matter, is an admirable manure for the turnip as a substitute for farm-yard dung.*"—*Jour. Roy. Agr. Soc. Eng.*, vol. viii. part 2, pp. 562-3.

We cannot now stop to point out various little discrepancies in Baron Liebig's professed quotations of figures; but there is one result, which he says is "still more incomprehensible," to which we must call attention. In this particular instance, we cannot entirely blame Baron Liebig, for it is a *misprint* in our own paper, that has supplied him with the strong point of his case; though, the evidence respecting the same experiment given in the immediately succeeding tables, would have saved any careful critic, from the blunder into which he has been led by the misprint. He quotes a plot manured with gypsum and rape-cake in 1845, and apparently yielding 18 tons 1 cwt. of turnips. Now it so happens, that in our paper, we spoke of the produce of the farm-yard manure of that year, which was 17 tons, as the highest in the entire series of the experiments. This certainly ought to have raised some doubt as to the correctness of the figures in question. The fact is, that instead of 18 tons 1 cwt. the produce was only 10 tons 1 cwt.; and this was shown by the relation of the average weight of bulbs and number of plants per acre, and by that of the acreage produce of leaf, and the proportion of the latter to 1000 of bulb, as given in the tables which immediately succeeded.

To say nothing of minor discrepancies which also appear, the following is the curious contrast which we obtain, between Baron Liebig's comment, and that which is really consistent with the facts of the case. In the left-hand column is given Baron Liebig's comment, founded on the misprint; and in the right-hand one, the comparison is shown as it *would be*, according to the corrected figures. The italics are given to indicate the differences between the parallel passages in the two cases.

Principles, p. 127-8.	*Amended Comparison.*
"In 1845, another lot of equal size, manured with 12 cwt. of gypsum (the residue of the manufacture of tartaric acid), and 10 cwt. of rape-cake, yielded 18 *tons* 1 *cwt.* of turnips, that is, 6 *tons more* than the highest produce (12 *tons*) of the land	In 1845, another lot of equal size, manured with 12 cwt. of gypsum (the residue of the manufacture of tartaric acid), and 10 cwt. of rape-cake, yielded 10 *tons* 1 *cwt.* of turnips, that is, 3 *tons* 1¾ *cwt. less* than the highest produce (13 tons 2¾ cwt.)

least, and we could in others, that 'Proposition 14' is not the only one, which records an advance upon Baron Liebig's previous views.

manured with bones and sulphuric acid, and *nearly* 10 *tons more* than its average produce, or *more than double* of this last, which was $8\frac{1}{4}$ tons."

of the land manured with bones and sulphuric acid, and *only* 1 *ton* 16 *cwt. more* than its average produce, which was $8\frac{1}{4}$ tons. *But, gypsum without rape-cake gave* 7 *tons* 9 *cwt. less than the highest by superphosphate of lime in the same year; and* 2 *tons* 11 *cwt. less than the average produce of the latter!*

Baron Liebig's numerical comment on this "still more incomprehensible" result is therefore simply reversed. But let us now see how far his comparison was legitimate, even supposing his numbers had not been erroneous. The real fact was, then, that gypsum used *alone*, though even after apatite (phosphate of lime) in great excess in the previous year, gave only 5 tons 14 cwt. of produce. *This*, as the result of purely mineral manure, was that which, *in fairness*, should have been compared with the "12" or rather 13 tons $2\frac{3}{4}$ cwt. yielded by the phosphate of lime and sulphuric acid in the same season. Again, 7 tons 10 cwt. was the produce of 10 cwt. of *rape-cake*, *when used alone;* and when to this latter amount is added, that portion of the 5 tons 14 cwt. by gypsum alone, which may be supposed not to be due to the previous dressing of finely powdered apatite, there is certainly nothing anomalous in the fact, that the gypsum and rape-cake together, gave 10 tons 1 cwt. of turnips.

It is, then, after such comparisons as those which we have pointed out, and on an incorrect statement as to our conclusions, that Baron Liebig says of our results, "In what incomprehensible contradiction do they stand to the opinions of Mr. Lawes!" And he adds—

"It is out of the question, after the facts just related, to assume that the excess of phosphoric acid was necessary, and was the cause of the increase. Is it then the sulphuric acid, the lime, or both together (gypsum), or is it the organic matter in the stable manure and in the rape-cake?"—*Principles*, p. 129.

To this we answer—that, *where the superphosphate of lime was used*, "it is out of the question after the facts just related," *to doubt*, that the action of "the excess of phosphoric acid," or of the phosphate of lime, "was the cause of the increase", *in that particular case!*—or, that *where the farm-yard manure or rape-cake was used*, "the organic matter thus supplied," together with the mineral constituents they contained, played an important part in providing the actual substance of the increased crop.

What, then, is the result of our examination of Baron Liebig's criticism on our experiments and conclusions regarding the growth of turnips? It is seen—that his statement of our general conclusion is *incorrect;* that his allegation as to the amount of phosphate

of lime we used is *an assumption and erroneous;* that his objections to admitting an action by an apparent excess of phosphates are *captious and unfounded;* that his "incomprehensible" facts are *comprehensible and consistent;* and that his "still more incomprehensible" fact is not even a fact at all, but is founded only on an easily discoverable *misprint!*

But after all this strenuous resistance of the notion, that in the *agricultural*—that is, in the *artificially enhanced*—growth of plants, there may be required a supply of substances by manure, beyond that which can be accounted for by any idea of merely supplying what is to become an actual constituent of the removed crop—and saying with regard to it, "have we made, after all, but a hair-breadth's progress from our old position?"—we find, but a page or two further on, the enunciation of a general principle, obviously intended to cover any such instances which it may be impossible to deny the existence of as facts. Baron Liebig says:—

"As a general rule, the manuring of a field *should not be calculated from the sum total of the mineral ingredients which the plant takes from the soil, but must be proportional to that maximum of these substances which is required by the plant in a certain period of its growth.*"—*Principles*, p. 133 (note).

We would compliment Baron Liebig on the fact, that we have here evidence of more than "a hair-breadth's progress from our old position," when we contrast that which is herein involved, with his general conclusions on the subject of manuring, in summing up his *general retrospect*, in the fourth and last edition of his main work, where he says:—

"By an exact estimation of the quantity of ashes in cultivated plants, growing on various kinds of soils, and by their analysis, we will learn those constituents of the plants which are variable, and those which remain constant. Thus also we will attain a knowledge of the quantities of all the constituents *removed from the soil by different crops.*

"The farmer will thus be enabled, like a systematic manufacturer, to have a book attached to each field, in which he will note *the amount of the various ingredients removed from the land in the form of crops, and therefore how much he must restore to bring it to its original state of fertility.* He will also be able to express in pounds weight, *how much of one or of another ingredient of soils he must add to his own land, in order to increase its fertility for certain kinds of plants.*"—*4th Edition*, p. 212, 213.

And then again, to cover by general principle, the undoubted fact, that the resultant requirements of land under cultivation, are certainly not to be ascertained by the consideration of the collective mineral composition of the crop to be grown, we are told:—

"The produce of a field stands related to the amount of that mineral ingredient which its soil contains in *smallest quantity.*"—*Principles*, p. 133 (note).

And this simply common-sense notion (provided that smallest quantity be too small for the requirements of a maximum growth),

but which, however, is the clear way of escape from his previous applications of his doctrines, and a net large enough to include many now established facts inconsistent with those applications, is insisted upon much more at length in Baron Liebig's recent reply to the criticisms of his 'Principles' by Professor Wolff.

In like manner, the careful reader will observe throughout all Baron Liebig's writings in this discussion, that, whenever there is a fact to be admitted, or a deviation from the exact expression previously given to his views to be conceded, we are first favoured with a general or abstract statement; perhaps obviously true, and perhaps so little differing from previous forms of expression in individual sentences of his works, as to pass unobserved, and yet sufficient to claim the fact or conclusion which he has to record and admit, as but an obvious consequence. The following is a further illustration of this mode of ignoring the experimental evidence and conclusions of others, and of netting the whole as an obvious consequence from his own principles.

The reader need scarcely be reminded of Baron Liebig's argument on Boussingault's rotations, viz., that the nitrogen of his manure had done nothing; and that if the latter had been burnt, and its nitrogen expelled, the produce would have been the same;—that, in defining agriculture as distinguished from normal vegetation, he has said, that the nitrogen yielded to the latter by the atmosphere was "*quite sufficient for the purposes of agriculture*;"—and that, speaking of produce grown under cultivation, that is, in agricultural quantity, he has said—"Surely the cerealia and leguminous plants which we cultivate must derive their carbon and nitrogen from the same source whence the gramineæ and leguminous plants of the meadows obtain them!" But what are we *now* told? And how is the very opposite of this, the clear recognition of which we have maintained to be the very key to advancement in agricultural science, now swept into accordance with Baron Liebig's own principles by general and abstract statements, obviously true, and put apparently with little reference to any point in dispute?

"But the *quantity* or amount of produce is in proportion to *two factors*, namely, the *atmospheric* food of plants, and their *terrestrial* or *mineral* food. This quantity depends on the presence of both, and on their co-operation in due proportion, and in the proper time.

"If the amount of one of these factors—*the mineral food of plants*—be increased, while that of the other—the *carbonic acid and ammonia*, which can be conveyed to the plants by means of the atmosphere—remain unchanged, the amount of carbonised and nitrogenised produce cannot thereby increase; but the crops, in this case, will vary with the absorbing or active surface of the plants cultivated on the land."—*Principles*, p. 76.

He then goes on to state that "the air contains a very limited amount of carbonic acid and ammonia," and that—

"It is obvious that, if we could double or treble the proportion of carbonic acid and ammonia in the air, the plants would, in the same circumstances, take up twice or thrice as much carbonic acid and ammonia in the same time, or as much as they could do in the normal condition in twice or thrice the time."—*Ib.* 77.

Here, then, we are told, that the supplies of carbonic acid and ammonia in the atmosphere, though enough for *normal vegetation*, are "very limited." Surely, however, they still remain as before, "*quite sufficient for the purposes of agriculture*"? Baron Liebig answers this question thus:—

"But the weight or amount of the crops is in proportion to the quantity of food of both kinds, *atmospheric* and mineral, which is *present in the soil*, or conveyed *to it* in the same time. *By manuring with ammoniacal salts a soil rich in available mineral constituents, the crops are augmented in the same way as they would have been if we had increased the proportion of ammonia in the air.*"—*Ib.* 77, 78.

How neatly, then, has Baron Liebig here begged the whole question of the necessity in *agriculture* as distinguished from natural vegetation, of an accumulation of available nitrogen *within the soil itself!* How curiously, too, are the very circumstances, under which we have previously been told that our crops are the *most* capable of relying upon the atmosphere for their nitrogen—namely, those of *mineral richness—now* made the very conditions under which the supply of ammonia to the soil is *most necessary!* Thus, speaking of the supply of ammonia, he says—

"that it may be even superfluous, *if only the soil contain a sufficient supply of the mineral food of plants*, when the ammonia required for their development will be furnished by the atmosphere."—*4th edition*, p. 212.

And again:—

"If the soil be suitable, *if it contains a sufficient quantity of alkalies, phosphates, and sulphates*, nothing will be wanting; the plants will derive their ammonia from the atmosphere as they do carbonic acid." (!)—*Translation of Letter, Farmer's Magazine*, vol. xvi. p. 511.

But not only does Baron Liebig do this, but he claims it as the established principle of his previous writings, that it is for "*wheat*" distinctively, that ammonia must be added in the manure. Thus he goes on to say:—

"This is the meaning of the passages above quoted from my work, which tell the agriculturist that, in order to raise the produce of his land above a certain point, in the case of such plants as have not many leaves—*for example, of wheat*—he must add ammonia in the manure."—*Principles*, p. 78.

Here, then, the importance of nitrogen in the soil for *wheat*, as distinguished from other crops, is claimed as a conclusion established by "the passages above quoted." But strange to say, after thus attempting to claim that which is now so far an established fact, that it would be only ridiculous to deny it,

Baron Liebig in the very next page, when the object is to refute our statements, and not to claim the truth as his own, says:—

"It is not easy to understand how Mr. Lawes could deduce from his results the conclusion, '*that nitrogenised manures are peculiarly adapted for the culture of wheat*,' . . . ."!

Now, it so happens, that in "the passages above quoted," not one word was said of such plants as have not many leaves —"for example, of *wheat*." The reference was to *annuals generally;* and runs thus—"The food contained in the atmosphere does not suffice to enable *these plants* to obtain their maximum of size in the short period of their life." These plants, *the annuals*, include of course equally "*cerealia* and the *leguminous plants which we cultivate*," of which Baron Liebig has told us, that surely they "must derive their carbon and nitrogen from the same source whence the gramineæ and leguminous plants of the meadows obtain them." But notwithstanding that Baron Liebig has told us in so many forms in his previous works, that the nitrogen supplied by the atmosphere is sufficient for the purposes of agriculture, and also that the *cereals* and leguminous crops of our rotations are equally independent of nitrogen in the soil with the meadows, he now tells us that his meaning in those previous works was, that—for the growth of certain plants—"for example, of *wheat*"—the agriculturist must add ammonia in the manure! The reader will judge for himself then, how far it is candid, or just, or strictly consistent with truth, that Baron Liebig should now seek to include by a statement of general principles, and by stretching and explaining the meaning of individual sentences of his previous works, facts and conclusions since established; and which are not only *fundamental*, as leading to the true explanation of the main features of agricultural practice, but which are further flatly contradicted by other individual sentences of his works, and are, by the concurrent testimony of every competent writer on the subject, inconsistent with the *main*, *prominent*, *and most characteristic features*, of his previously promulgated doctrines?

Another instance of this kind will come to light, in considering Baron Liebig's comments on that part of our criticism of his views, which led to the attack on our experiments and conclusions in reference to the growth of turnips. In one of our papers we had said:—

"But it is at any rate certain that phosphoric acid, though it forms so small a proportion of the ash of the turnip, has a very striking effect on its growth when applied as manure; and it is equally certain that the extended cultivation of root crops in Great Britain cannot be due to the deficiency of this substance for the growth of corn, and to the less dependence upon it of the root crops, as supposed by Baron Liebig."—*Jour. Roy. Agr. Soc. Eng.*, vol. xii., part 1, p. 35.

This comment we had made in reference to a sentence in Baron Liebig's 'Letters,' wherein, speaking of the exhaustion of phosphate of lime and alkaline phosphates, by the sale of flour, cattle, &c., he says:—

"It is certain that this incessant removal of the phosphates must tend to exhaust the land and diminish its capability of producing grain. The fields of Great Britain are in a state of progressive exhaustion from this cause, as is proved by the rapid extension of the cultivation of turnips and mangold wurzel—plants which contain the least amount of the phosphates, AND THEREFORE REQUIRE THE SMALLEST QUANTITY FOR THEIR DEVELOPMENT."—*Letters*, 3rd Edition, p. 522.

On this sentence we further commented thus:—

"Now, we do not hesitate to say that, however small the quantity of phosphates *contained* in the turnip, the successful cultivation of it is more dependent upon a *large supply* of phosphoric acid in the manure than that of any other crop."

Baron Liebig thus meets these comments,—

"No one surely can believe that my statement as to the very small proportion of phosphates in turnips is untrue, *because* Mr. Lawes has misunderstood the meaning of the sentences above quoted from my work. My remarks had no reference whatever to the manuring of turnips, but were designed to direct attention to the difference between turnips and other crops which require in certain periods of their growth more phosphates than turnips do. With reference to the cultivation of grain, I wished to show that the growth of turnips had acquired so vast an extension [the italics are Baron Liebig's own], *for this reason*, namely, *because the soil loses so little of the phosphates by the cultivation of the latter crop.* Turnips are so advantageous in a rotation, only because, whatever be the quantity of phosphates contained in the soil, or added to it in the manure, they leave in the soil so large an amount of these indispensable salts for other crops, which require a larger supply of them."—*Principles*, p. 131.

Farther on, Baron Liebig refers the reader to the letter in question, to justify the meaning which he has now given to his sentence, and to convince him that we do not do him justice. Now we must say, that we have carefully re-perused that letter; and still maintain, not only that if language has any meaning at all, we *have* done Baron Liebig entire justice in the interpretation of his sentences which we have given of them, but that, by no interpretation of language, can the meaning which he now claims be given to his argument as formerly put forth. Certainly nowhere have we previously been told by Baron Liebig that—

"Turnips are so advantageous in a rotation only because *whatever be the quantity of phosphates contained in the soil, or added to it in the manure, they leave in the soil so large an amount of these indispensable salts for other crops* which require a larger supply of them."

Baron Liebig's statement was, not only that turnips were "plants which *contain* the least amount of the phosphates," but that they "*therefore* require the smallest quantity for their develop-

ment." Whereas our own statement is, that, however small the amount of phosphates *contained* in a removed crop of turnips, they *require a large amount for their development.* And if it be really a well-established fact, that, however small may be the quantity of phosphates lost to the farm by the growth of turnips, still a much more liberal supply is required in the soil for the production of a full agricultural crop of them than of corn, it is then obviously impossible, that the progressive exhaustion of the phosphates, could be the cause of the extended cultivation of the former. In fact, there can be no doubt, that such an exhaustion would be a far greater obstacle to the extended growth of roots than of corn.

But with regard to the effects of an artificial supply of phosphates, upon the increased production of corn, Baron Liebig further says:—

"We believe that the importation of 1 cwt. of *guano* is equivalent to the importation of 8 cwt. of wheat; the hundredweight of guano assumes in a time which can be accurately estimated, the form of a quantity of food corresponding to 8 cwt. of wheat. The same estimate is applicable in the valuation of bones.

"If it were possible to restore to the soil of England and Scotland the phosphates which during the last fifty years have been carried to the sea by the Thames and the Clyde, it would be equivalent to manuring with millions of hundredweights of bones, *and the produce of the land would increase one-third, or perhaps double itself, in five to ten years.*

"We cannot doubt that the same result would follow *if the price of the guano admitted the application of a quantity to the surface of the fields, containing as much of the phosphates as have been withdrawn from them in the same period.*"—*Letters*, 3rd edition, pp. 523, 524.

How far the increase in the produce of wheat by the use of *guano*, is measurable by the amount of *phosphates* it supplies, the practical farmer may judge from the fact, to which we have before called attention, namely, that 1 *cwt. of Peruvian guano will supply as much phosphoric acid* as would be contained in about 18 *bushels of wheat and their equivalent of straw, say* 1800 *lbs.;* and that of *nitrogen*, 1 cwt. of guano will contain *about as much as* 11 *bushels of wheat and* 1100 *lbs. of straw.* But, if we were to assume, that one-third to one-half only, of the nitrogen supplied in manure for the growth of wheat will be obtained in the increase produced, we should have on this calculation, 4 or 5 bushels of corn, and their equivalent of straw, by the use of 1 cwt. of guano. We leave it with the practical man to judge, whether these last amounts, or 18 bushels of corn with their equivalent of straw, are more nearly those which in practice he obtains, by the use of 1 cwt. of guano.

Baron Liebig proceeds:—

"If a rich and cheap source of phosphate of lime and the alkaline phosphates were open to England, there can be no question that the importation

of foreign corn might be altogether dispensed with after a short time. For these materials England is at present dependent upon foreign countries, and the high price of guano and of bones prevents their general application, and in sufficient quantity. Every year the trade in these substances must decrease, or their price will rise as the demand for them increases.

"According to these premises, it cannot be disputed, that the annual expense of Great Britain for the importation of bones and guano is equivalent to a duty on corn: with this difference only, that the amount is paid to foreigners in money."—*Letters*, 3rd edition, p. 524.

Now, that the efficacy of guano for the production of *corn*, is measurable by the amount of nitrogen, and not by that of the phosphates which it contains, is obvious from the simple facts,—that guano rich in nitrogen and relatively poor in phosphates, will command twice the price of one rich in phosphates and poor in nitrogen,—and that all experience shows, that the dearer guano, rich in nitrogen and relatively poor in phosphates, yields a far greater increase of grain, than that which is cheaper and contains more of phosphates and less of nitrogen. But, with regard to Baron Liebig's supposition, that if a rich and cheap source of phosphates were open to England, we might soon be independent of foreign corn,—since we now have such a source, this opinion is worth a little examination. It is probable, that from 20 to 25 per cent. of the corn consumed in this country, is imported. Unless, therefore, a very much larger breadth of land were brought under corn, it is obvious that, to attain this happy result, the whole of our wheat-fields must yield from one-fourth to one-third more produce than at present. Whether or not it is likely that they would do so by the use of *phosphates*, even if mixed with alkalies, provided that available nitrogen were not at the same time added, the results not only of our own experiments, but the experience of every farmer who has ever used an artificial manure, will at once decide.

Fourthly—We proceed to illustrate, by condensed summaries of an immense mass of experimental results, and a very rapid consideration of their indications, some prominent points connected with the action of manures on the different crops of rotation, and with the chemical circumstances involved in fallow and a rotation of crops. The first of these points, namely, the characteristic action of certain constituents of manure, upon the most important crops grown in our rotations, is illustrated in Table IV. which follows; and, for the purpose in question, *wheat* and *barley* have been selected as cereals; *turnips* as a *root-crop*; and beans and clover as leguminous plants.

TABLE IV.

Summary—showing the characteristic action of Manures on different Crops. Average Increase of Produce per Acre.

Constituents of Manure (used separately or combined).	Cereals.				Leguminous Crops.		Roots.	
	Wheat.			Barley.	Beans.	Clover	Turnips.	
	Woburn.	Holkham.	Rothamsted.					
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	tons.	cwts.
1. Potass	..	..	..	..	938	1017	..	
2. Potass, soda, and magnesia . . .	..	..	270	none.	843	1221	..	
3. Superphosphate of lime	..	..	414	242	none.	113	7	1¼
4. Do. do. and potass .	..	..	97	..	505	1580	5	8
5. Nitrate of soda	..	..	2332	1870	..	..	..	
6. Ammonia salts	1640	1442	1714	2317	14	none.	0	6¼
7. Ammonia salts and superphosphate of lime	..	..	2511	2828	175	none.	8	15¾
8. Ammonia salts, potass, and superphosphate of lime	..	..	2956	..	850	1086	9	16¼
9. Ammonia salts, potass, soda, magnesia, and superphosphate of lime	1757	2357	3035	3154	1367	925	10	12¾

Each entry in this Table (IV.) indicates the average *increase* per acre, calculated from all the eligible cases, throughout the entire series of experiments with the different manures and crops, and extending in most cases over several seasons. The method of the estimation is as follows:—namely, to find the *increase* in each case, or average of a number of cases, occurring in any particular season, by deducting from the total *produce* by any particular constituent or constituents of manure, that obtained without manure in the same season; and an annual average is then taken of the increase thus obtained for the several seasons.

In such a summary as is here given, we cannot expect exact numerical consistency in apparently similar cases, the results being frequently the average of very different seasons; but we cannot fail to find prominent indications of the broad and characteristic effects of the respective manurial constituents or combinations on the respective crops. And, since in all cases (unless otherwise mentioned) the indications are derived from the growth of the crop in the manner described through several consecutive seasons, the *characteristic* exhaustion or requirements of the several crops, is thus very prominently brought to view.

The manurial conditions enumerated in the first column of the Table, may be further explained, thus:—

Potass, soda, and magnesia—generally as sulphates.

Superphosphate of lime—bone ash, mixed with water, and decomposed by three-fourths of its weight of sulphuric acid, sp. gr. 1·7.

Nitrate of soda—commercial.

Ammonia salts—generally an equal mixture of the sulphate and muriate.

As already stated, the crops brought into this review, are wheat, barley, beans, clover, and turnips. In the case of wheat, barley, and beans, the figures represent the *total* increase, including both corn and straw; in that of clover the increase is given for the sake of comparison, in somewhere about the same state of dryness as the corn crops, that is, to the weight of the *dry matter*, one-sixth is added for water; and that of turnips includes both leaf and bulb in the fresh state as weighed.

At an earlier page, we have called attention to the fact, that Baron Liebig being obliged to admit the influence of nitrogenous manures in yielding an increase in wheat in the experiments on our own land, asserts that such a result is simply exceptional; and that from it no conclusion can be formed as to what would happen on any other lands of different quality. On this point he says:—

"Had Mr. Lawes asserted, that on his land, in the given circumstances, ammonia and ammoniacal salts were found to be peculiarly favourable to the growth of wheat; and that, leaving the price out of view, these salts, under similar circumstances, formed the best manure, he would simply have confirmed a result predicted by theory. But even if his assertion had been given as an entirely new discovery, there could have been nothing urged against it.

"If, however, we extend his conclusions to any other land of different quality, and placed in different preliminary conditions, it will appear entirely erroneous; for it can be proved, in the same way, and by facts equally decisive, that ammoniacal salts alone, in thousands of wheat-fields, do not in the smallest degree increase the produce; and that, in thousands of other such fields, these salts do increase the produce for a year, or for two years, and that then a farther application of them to the same land is found to be utterly without effect."—*Principles*, p. 79, 80.

"The results of Mr. Lawes have no value for his next-door neighbour, nay, they have no value for himself; for the *recipe*, to which he comes, only applies to his own lands, and to them only in so far as experimented on, and only for a very limited number of years."—*Ib.*, p. 105.

"It is altogether incomprehensible that it should never for one moment have occurred to Mr. Lawes, that in Germany, France, and even England, all land has not the quality of his land."—*Ib.*, p. 120.

Now we have already shown, that whatever the natural quality of our own land, and whatever the amount of its annual produce under the influence of natural soil and season supplies, it was nevertheless, in an agricultural sense, in a state of corn-exhaustion, induced by the growth of a succession of crops in the ordinary course of farming, but without receiving any manure after the commencement of the course. It was, indeed, brought into such a state, that its produce was very far below that which might have been obtained by the ordinary means of restoration. We further maintain, that the nature of the exhaustion which the results of these experiments showed our field to have un-

dergone, is precisely that which all experience shows (and we have perhaps opportunities of information on this point second to none) to be the *characteristic* exhaustion induced by the growth of grain in an ordinary course of rotation with insufficient home-manuring. Upon the truth of this statement, which no results of direct experiments on individual soils would, we suppose, be admitted to substantiate, we are content to rest the credit and validity of our conclusions generally. More than this, however, is insinuated by Baron Liebig,—namely, that we would recommend the application of ammonia-salts alone, on all soils, and for the continuous growth of corn as an agricultural practice:—*This we have never done.**

Some of the results in Table IV. will, however, distinctly show, that the "recipe," as Baron Liebig calls it, to which we come, is not only applicable to our "own lands, and to them only in so far as experimented on," but that this so-called "recipe" is applicable to "other land of different quality". Thus, under the head of *wheat*, we have in the Table the results obtained by the use of ammonia-salts, both used alone and with a full supply of minerals, not only on our own land, but on that of the Duke of Bedford at Woburn, and of the Earl of Leicester at Holkham; and, as will be seen by the description given below, the character of the soil in these two cases differed very widely, both from each other, and from our own. In some particulars, indeed, especially at Woburn, the description of land is such, that if it were possible to get from any ordinary cultivated soil, a result inconsistent in the main with our own, we should, according to the notions of Baron Liebig, be led to anticipate that it would be here most manifest.

The soil upon which the experiments at Holkham were made is described by Mr. Keary, as a "light, thin, and rather shallow brown sand-loam," but "resting upon an excellent marl, which contains a large quantity of calcareous matter." Mr. Keary adds, that he finds these light sand-loams, *with the above subsoil*, "to be most productive and grateful for *high-farming*."

Mr. Baker describes the land allotted to the experiments at Woburn as follows:—

"The land these experiments are upon is what I consider a very poor description of *sand*, on a particularly wild sandy subsoil. . . . The land has been farmed on the four-course system, I think I may say for twenty-five years, and previous to that was open heath-land. This, as you are aware, is the *fifth season the plots have had wheat upon them in succession*."

Now, if it were possible to find a soil under ordinary cultivation, which, according to the suppositions of Baron Liebig,

* On this point, see Report of Experiments on the Continuous Growth of Wheat at Holkham Park Farm, in the last number of this Journal.

would not give an increase of wheat by the use of ammonia-salts alone, and that would, after one or two years, be strikingly benefited by the application of mineral manures, it would be such a one as has been last described. Let us see what are really the facts of the case.

By the use of ammonia-salts alone, an average total increase was obtained of corn and straw, per acre, at Woburn of 1640 lbs., at Holkham of 1442 lbs., and at Rothamsted of 1714 lbs. And when to the ammonia-salts a liberal supply of minerals was added, the total increase became at Woburn 1757 lbs., at Holkham 2357 lbs., and at Rothamsted 3035 lbs.

As the seasons in which these results were obtained were not the same in all the three cases, no precise quantitative comparisons can be made. But it is a curious fact, that the soil at Holkham, which is described as having at any rate a good subsoil, was more benefited by the addition of a full supply of mineral constituents, than that at Woburn. And again, the soil at Rothamsted, assumed by Baron Liebig to be so exceedingly rich in minerals, gave a greater increase by the combination of *minerals* with a large supply of nitrogen, than was obtained in either of the other cases.

It is established, then, by direct experiment, that the "recipe" to which we come, is not applicable *only* to our "own lands, and to them only, in so far as experimented on." And also, that if we extend our conclusions to "other land of different quality," they are *not* necessarily "entirely erroneous."

Let us now again refer to Table IV., and contrast the effects of characteristic constituents, or combinations of manure, upon some of the most important of our agricultural crops; which stand in relation to each other, in very different positions in our rotations.

We may first premise, that owing to the great liability to disease in the leguminous crops, *especially when grown continuously*, the final produce in their cases, was frequently much less than it promised to be in the earlier stages of growth. The results relating to beans, are in all cases the averages of several seasons; and those in regard to clover, apply to the years 1849, 1851, and 1852, wheat being the crop in the intermediate year; and, as will readily be understood, the produce in the two last years, was both meagre and irregular as compared with that on the same plots in 1849, in which season the crop was very large. For the sake of comparison with the other crops, the clover is given as before stated in about the same state of dryness as the beans and grain; that is to say, the figures in the Table represent the *dry substance*, *plus* one-sixth of its weight of water.

It will be observed, that with a manure of *potass* alone, the

two leguminous crops (beans and clover) give a very considerable *average* increase ; though in individual years, it was very much greater than this Table of averages merely, would indicate.

A mixture of *potass*, *soda*, and *magnesia*, gave with wheat a small average increase ; with the other cereal, barley, there was, taking the average, a slight deficiency. But, with beans and clover, this supply of alkalies produced a considerable increase.

Superphosphate of lime has given with the cereals a small average increase ; with beans on the average there was a deficiency ; with clover a very small increase ; but with *turnips*, an average increase of total produce, of more than 7 tons.

When to the *superphosphate of lime*, *potass* is added, we get scarcely any increase with wheat ; a notable increase with beans, though less than when the potass is used alone ; a very considerable increase with clover ; and with turnips, a considerable though less amount of average increase than when the superphosphate of lime was used without the potass.

Nitrate of soda gives with both the cereals, a very considerable increase.

Ammonia-salts also gave with both the cereals a large amount of increase ; and in the case of wheat a large increase was obtained in other soils of very different quality, as well as at Rothamsted. These ammonia-salts, however, which with the comparatively speaking deficiently nitrogenised cereals, give such a large amount of increase—with the highly nitrogenous leguminous crops, give in the case of the beans an average of only 14 lbs. of increase, and with the clover an actual deficiency. And with turnips, we have with ammonia-salts alone, only a few hundredweights of increase, instead of more than as many tons with superphosphate of lime.

The mixture of superphosphate of lime, with a large amount of ammonia-salts, gives a greater increase with both wheat and barley, than the ammoniacal salts alone. With the leguminous crops, the mixture of ammonia-salts and superphosphate of lime, yields scarcely any beneficial result ; indeed with clover there was on the average a deficiency. It should be stated, however, that owing to the injurious effects observed on the use of much ammonia-salt with the leguminous crops, the quantities employed per acre in the cases in question, were much less than with the cereals. In the turnip experiments, also, much less of these salts was found to be appropriate than in the case of the grain crops, and less therefore was employed. Although when used alone, the ammoniacal salts gave no appreciable result with turnips, yet, when mixed with superphosphate of lime, they increased the efficacy of the latter manure. Thus, we have with the mixture $8\frac{3}{4}$ tons of increase of gross produce of turnips,

instead of only about 7 tons with the superphosphate of lime alone.

The addition of *potass*, to a mixture of superphosphate of lime and ammonia-salts, gives a still further increase in the case of wheat. With the leguminous crops we have now again a striking increase, and with turnips also a considerable one.

Lastly,—a mixture of ammonia-salts, and a liberal mineral manure, containing superphosphate of lime, potass, soda, and magnesia, gives a very large increase with every one of the crops enumerated. The efficiency of a full supply of minerals, is seen to be very marked even with the cereals, when mixed with a large amount of the ammonia-salts; that is to say, when these crops (the cereals) are supplied, at the same time, with such an amount of *available nitrogen in the soil*, as, when used alone, gives a produce nearly equal to that which would usually have been obtained in the ordinary course of farming. The mixture of ammonia-salts with minerals does not, however, with the leguminous crops, give obviously more increase than when the minerals, and especially the *alkalies*, are used alone. And again, the result upon the *turnips*, of this full manuring—supplying as it does every important constituent except carbon—shows that which we have elsewhere so prominently maintained, namely, that however much the healthy growth of that crop may be increased by the direct use of *mineral*, and especially of *phosphatic* manures, yet that for the production of a full crop, *a supply within the soil of matter for organic formations* is quite essential. And, had we further extended the plan of our Table, so as to show the effects of manures containing carbon, it would have been seen, as we have frequently pointed out, that such a supply yielded a more characteristic result with the roots than with the other crops enumerated; next in order to these would probably come the leguminous crops; and lastly the cereals, which are benefited least of all by manures supplying carbon.

A study of this condensed summary of a vast collection of facts will be found highly instructive. As a main result it may be stated, that the average increase by mineral constituents alone is with the cereals less than 200 lbs., whilst with the leguminous crops, even though including so many cases of really deficient crop arising from disease, it is four times as much. On the other hand, the *cereal grains* give an average of from 1800 to 2000 lbs. of increase with nitrogenous manure alone; whilst by the same manure there was on the average, with the leguminous crops, not any increase at all. Then again, with turnips, we have by mineral manures alone, an average increase of gross produce of about 6¼ tons, but with ammonia-salts alone, of only as many hundredweights. But, if we still more carefully compare

the action of the several individual constituents of manure, with that of their several combinations, upon each of the different crops, and then again crop with crop, we cannot fail to see, that the general result is entirely inconsistent with that which the collective analysis either of the crops or of their ashes would have led us to, had this alone been our guide. Finally, in prominent outline, the result is seen to be, that for the production of increased growth *nitrogenous manures* had the *most characteristic* effect upon the *cereals; potass* on the *leguminous crops;* and *phosphates* on *turnips.*

There is another very important point connected with *manuring*, in relation to which we must here adduce some experimental evidence, and a few observations. The subject, however, is one which, both from its extent and importance, demands that a separate paper should be devoted to its elucidation; we therefore the less regret the very cursory manner in which we are now obliged to notice it.

The point to which we refer, is the constantly observed fact throughout our experiments, that, although an increased production of the cereal grains (the main saleable produce, and, as it were, the final product to which all farming operations tend) is only attainable in agriculturally adequate amount, by the accumulation of available nitrogen *within the soil itself;*—yet, in no case have we recovered in the increase of crop obtained, as much nitrogen as was supplied to the soil in manure. Now, if it be proved, that increase of the *cereal grains* in agricultural quantity, is essentially connected with the supply to the soil of much more nitrogen than is recoverable in the increased produce obtained, it will be obvious, that we have here a fact, which must fundamentally affect the views we entertain as to the principles involved, not only in direct manuring, but in those other main features of agricultural practice, which are had recourse to with the same result.

In relation to this subject, we have in our various papers, prominently called attention to several of the main facts which our experiments have brought to light. Thus, we have shown that, after supplying to the soil twice or thrice as much nitrogen as was obtained in the increase yielded, there was in the succeeding year, either no increase whatever due to the nitrogen not recovered in the year of its application, or that such increase in the second year, if any, was not only extremely small, but that it occurred only when the application of the previous year, had been obviously very excessive in relation to the climatic or other circumstances of growth of the particular season. We have also called especial attention to the fact, that the increase produced by a given amount of nitrogenous supply is very variable, according to the

variations of season, and of other coincident conditions of the growth and maturation of the crop.

But, Baron Liebig in his criticisms equally ignores our facts, our observations, and our conclusions regarding them! With a view of maintaining that the increase of produce obtained was *not* proportional to the supply of ammonia by manure, and consequently that the results of our own experiments demonstrated the contrary of that which he alleges we have concluded from them, Baron Liebig compares the increase by a given amount of ammonia in *different seasons*, without any reference either to the *varying character of those seasons*, or to the fact, that in recording the experiments of which he treats, *we had ourselves called particular attention both to the actual variations, and to their influence upon the results in question.* Thus he selects for his purpose, results obtained in the several seasons of 1844, 1845, and 1846; and shows that in the last (1846), the increase obtained from a given amount of ammonia-salt in manure, was once and a half or twice as great as in the other cases. In reference to this very point we had said :—

"It should be remembered, however, that as the season of 1846 was more than usually favourable to the production of corn, any calculations founded upon the results of that year *might lead to an over-estimate of what the ammonia would produce in an average of years.*"—*Jour. Roy. Agr. Soc. Eng.*, vol. viii. part 1, p. 247.

Again, speaking of the total amount of ammoniacal salts added to one of our plots (10*a*), in six years, he says :—

"But as the whole 1960 lbs. was not added in one year, but in portions during six years, the soil became each year richer in them than it was in the preceding. There remained a residue from the previous year, which was annually increased by the portion newly added."—*Principles*, p. 95.

He then, in direct contradiction to the evidence of our experiments, goes on to deduct from the amount of nitrogen supplied to the soil in each year, that amount which he supposes was contained in the increase of crop obtained by it; he assumes that the remainder accumulates from year to year, as a residue in the soil, the amount of which residue, taken together with that of the salt newly added, is to be considered as the amount of ammonia-salts yielding the increase of any particular year. In this way, by bringing forward from year to year an assumed efficient residue, which our experiments prove did not exist, he calculates the increase of produce in the sixth year as due to 1592 lbs. of ammonia-salts!—though 400 lbs. only was the amount added as manure in that year. In this way it is, he arrives at the conclusion, that the produce for a given amount of nitrogen *steadily diminished!* He says :—

"*But it is and remains undeniably certain*, that the proportion of ammoniacal

salts in the soil, whatever might be its exact value, must have increased from year to year, because ammoniacal salts (sulphate of ammonia and sal-ammoniac) are not volatile, and, *consequently, the unconsumed portion, or excess, must have remained in the soil. This being assumed as a fact which cannot be disputed,* these numbers establish the truth, already demonstrated by the earlier experiments, that the produce did *not increase in proportion to the increased proportion of nitrogen present in the soil*; but that, with the exception of the year 1848, the produce for the same amount of nitrogen *steadily diminished*."—*Principles*, p. 97.

It is after the wholesale ignoring of our recorded facts, statements, and conclusions, which these quotations imply, and after such reasoning upon the pure assumptions taken in their stead as we have pointed out above, that Baron Liebig, using the word "*proportional*" in the exact numerical sense (which he well knows is entirely inconsistent with all our evidence and reasonings on this question), sums up his criticism by saying:—

"Mr. Lawes has disproved *what he intended to prove*, namely, that the excess of produce in this case *is proportional to the quantity of ammonia present in the soil*;—that is, *he has proved that a single, double, or treble supply of ammonia does not give a single, double, or treble excess of produce*; but that this excess is a constant quantity."—*Principles*, p. 135.

Already, however, in Germany, America, and this country, Baron Liebig's treatment of this question has been prominently commented upon. And thus it is, that he has been obliged to recur to the facts and conclusions involved in this part of the subject. At the recent meeting of the British Association at Glasgow he undertook to deal with this question; and as the line of argument he then adopted was substantially that which he had already published in Germany in reply to the admirable strictures on his 'Principles' by Professor Wolff,* we shall, for convenience, refer to the translation of his own reply, made and published at his own (Baron Liebig's) request in America.†

In discussing this question, we need not for a moment entertain as an objection against observed collateral facts, Baron Liebig's argument, that if there be a loss of nitrogen in the growth of *increased* produce, there must necessarily be the same relation between the normal supplies of nitrogen and the amount assimilated under their influence on our unmanured plot. It must then be distinctly borne in mind, that it is of actually observed facts, in relation not to the growth of produce alone, but of an *increased amount* of produce by means of an accumulation of nitrogen within the soil, that we have now more particularly to speak. We may, however, say in passing, that we have frequently called attention to facts regarding the amount of constituents harvested over a given area of unmanured or equally manured

* Zeitschrift für Deutsche Landwirthe, 4en Heft.

† The Country Gentleman. Albany, N. Y., October 11, 1855, *et seq.*

land, in the cereals and leguminous crops respectively, which are calculated to give at least a direction to our conclusions, in reference to the assimilation of nitrogen in the case of an unmanured cereal plot. Thus, the striking fact appears, that under similar unmanured or mineral-manured conditions, the produce of nitrogen per acre, may be twice and a half or thrice as great in one and the same season, with the leguminous, as with the cereal crop. This relation, therefore, between the amount of nitrogen assimilated under given circumstances in the leguminous crop, as compared with the cereal, is strikingly similar to that which is found, between the nitrogen of manure and that in the *increased* produce of the cereal obtained by its use.

Baron Liebig further alleges against our conclusions, that we have no evidence that the unrecovered nitrogen did not remain in the soil for the use of the future crops; that we should have employed very much smaller amounts of ammonia-salts, to prove that the smaller did not give an equal increase of produce with the larger, as well as to ascertain the minimum amount of ammonia-salts required to produce a maximum effect; and further, that the assumption that 5 lbs. of ammonia is required to produce a bushel of increase is no expression of a natural relation between manure and crops. We shall examine these several allegations.

Firstly, then, as to the assertion, that we have no evidence that the unrecovered nitrogen of the manure, did not remain in the soil for the succeeding crops. Not only had *we* sufficient evidence on this point, but Baron Liebig had himself, in our own recorded results, the proof of it in the degree in which we have ourselves maintained it. What we say is, that even when ammonia-salts are not used in greater excess than is adapted for a full average effect in any given season, still, probably, only from one-third to one-half of the nitrogen so supplied, will be recovered in the increase obtained in the year of the application; that this unrecovered nitrogen will yield little or no increase in the succeeding year; that if, under these circumstances, ammonia be again added, we shall, other conditions being equal, again get a large increase of produce; and further, that if more ammonia have been employed than is suited to give a fair increase of crop on the average of seasons, even then the effect of the residue in the succeeding year will be, comparatively speaking, very trifling. The registry of facts in Table V. will illustrate the above statements.

We could multiply instances of this kind illustrating the point in question; but those here given are sufficient to *prove the fact*,—that a moderate supply of ammonia-salts to the wheat crop, did not leave any efficient residue for the succeeding season. And such a result, we maintain, is entirely in accordance with the

experience of practical farming in the use of guano, and other nitrogenous manures, for the increased production of the cereal grains.

TABLE V.—Showing the influence upon the Wheat Crop, in the second season, of Nitrogen supplied in Manure (but not recovered in increase) in the preceding season.

Plots.	Seasons.	Ammonia-salts employed.	With or without Minerals.	Increase of Total Produce (Corn and Straw per acre).
		lbs.		lbs.
10 *a.*	1845	336	none	2,093
	1846	224	none	1,374
10 *b.*	1845	336	none	2,093
	1846	none	none	49 (less)
8 *b.*	1847	400	minerals	2,715
	1848	none	do.	82
5 *a.*	1851	600	minerals	3,477
	1852	none	do.	468
5 *b.*	1851	600	minerals	3,778
	1852	none	do.	624

Secondly, Baron Liebig says—

"If it had accidentally occurred to Mr. Lawes to manure his field with 4, 5, or 6 cwt. of ammonia-salts, instead of with 3¼ cwt., and if in those cases the yield was *not increased* (*as we may with certainty assume would happen*), then he might with the same justice assert that the loss of ammonia is 6, 8, or 10 lbs. for every bushel of increased yield.

"Or if Mr. Lawes had applied ammonia-salts at the rate of 2 or 1 cwt., instead of 3¼ cwt. the acre, and then, after previous manuring with dissolved bones and silicate of potash, (whose action he has not taken at all into account), had harvested the same increase of 8 bushels; his conclusion that the soil suffers a loss of ammonia, would doubtless have been vastly modified. He has made the loss and not found it."—*The Country Gentleman*, Nov. 1, 1855.

And again—

"It never seems to have occurred to Mr. Lawes to determine the minimum of ammonia which was effective upon his field in producing maximum crops."—*Ibid.*

Doubtless it will be highly satisfactory to Baron Liebig to learn, that it *has* occurred to us to supply almost identically all the cases here demanded. Thus, instead of using only 400 lbs. of ammonia-salts, which is rather more than on the average of seasons is adapted to our soil, we have, over a series of years, employed 600 lbs. and 800 lbs. of these salts; and the result has been exactly the reverse of what Baron Liebig says "*we may with certainty assume would happen.*" That is to say,

the crop in those cases *was very considerably increased;* though, as might be expected, in a diminishing numerical proportion to the excessive amount of ammonia now added. Then again, we have used, through the same series of years, respectively 200 lbs. and 100 lbs. of ammonia-salts, with, in each case, a full supply of soluble phosphates and alkalies; so that we have here again supplied the exact conditions demanded; and also the means of determining the "minimum" amount of ammonia which was effective in producing a maximum crop. Here, too, the results are precisely contrary to those which Baron Liebig has supposed they would be, and on the assumption of which he says, that *then* "his conclusions that the soil suffers a loss of ammonia would doubtless have been vastly modified. He has made the loss, and not found it."!

The following is a summary statement of the results obtained by the use of these gradationary amounts of ammonia, over a period in each case of three years, namely, 1852-4 inclusive. And in order to show by the side of these results, about what amount of produce was obtained on the same soil by means which the practical farmer will be better able to judge of, we also give the average produce by farm-yard manure during the same seasons; and, by the comparison here afforded, it will be seen, that some of the supplied amounts of ammonia were very far in excess of what was required to give a produce equal to that by the annual supply of farm-yard manure.

TABLE VI.—Showing the effects upon the Wheat Crop of gradationary amounts of Ammonia in Manure.

	Total Increase per acre (Corn and Straw).
	lbs.
Average of 3 years with minerals and 100 lbs. ammonia-salts ..	760
Do. do. do. 200 do.	1,575
Do. do. do. 400 do.	2,915
Do. do. do. 600 do.	3,641
Do. do. do. 800 do.	4,555
Do. do. farmyard manure	3,022

Here it is seen that the 100 lbs., the 200 lbs., and the 400 lbs. of ammonia-salts, gave a gross increase of produce (corn and straw together), almost identically proportionate to the amount of ammonia in the manure. As we have already said, however, the largest of these amounts (400 lbs.) is somewhat more than on the average of seasons will yield the most favourable result; and if it be much exceeded, the proportion of straw

to corn in the gross produce obtained will be much increased. It should be further added, too, as some qualification of the exact figures of the Table, that since the three seasons over which our average extends, include one at least which was unusually favourable to the production of corn, the result by even the 400 lbs. of ammonia-salts, as here recorded, will be rather better than would be obtained over a more extended period of time. There was, however, a still further increase of produce when more ammonia was employed; though, as already stated, the ratio of increase diminished the more rapidly the greater the *excess* of ammonia added in the manure.

Upon the whole, then, the result strikingly stands out—that we obtained a considerably greater amount of produce by the use of *much larger* amounts of ammonia than those which Baron Liebig has pronounced to be *excessive*, and to the use of which he attributes the conclusion which he assumes to be so erroneous. It is further obvious that there was a very general uniformity in the proportion of increase obtained for a given amount of ammonia supplied, whether 400, 200, or 100 lbs. of its salts were added to the soil. Hence it follows, that if there were a loss of nitrogen when 400 lbs. of ammonia-salts were used, there must have been very nearly a proportionate amount of loss when the *minimum* quantity was employed; and consequently that the loss observed when the 400 lbs. was used could *not* be due simply to the supply of more nitrogen than was necessary for a *maximum* of produce, as maintained by Baron Liebig. In fact, *we have found the loss, and not made it!*

Again, Baron Liebig says :—

"The number 5, for the amount of ammonia, and the quantity 1 bushel for the increased yield, are not expressions for a natural relation between manure and crops. The first does not express the weight of ammonia necessary to produce a maximum of increase, equal to one, and ascertained by a series of observations, but is a mere stroke of fancy."—*The Country Gentleman.*

We will first show, by quotation from our papers, whether we have assumed "the number 5 for the amount of ammonia, and the quantity 1 bushel for the increased yield," as an *unconditional* and *undeviating* relation; or whether these numbers are not given simply as a practical average of our experiments, admitting deviations on either side, according to variations of season and other circumstances. Secondly, we will show whether or not that which we have assumed, is "ascertained by a series of observations," or whether it is "a mere stroke of fancy." In regard to the first of these points, we say :—

"I am inclined to think that, for practical purposes, we may assume 5 lbs. of ammonia to be required for the production of every bushel of wheat beyond

the natural yield of the soil and season; at any rate, it will be useful to remember this as the amount until future experiments shall furnish further information on the subject."—*Jour. Roy. Ag. Soc. Eng.*, vol. viii., part 1, p. 246.

"We may here observe that the production of straw, as well as that of grain, would seem to be intimately connected with the expenditure of nitrogen derived through the roots of the plant, and had we time to consider the question more fully on this occasion, we should not have dwelt so exclusively on the production of corn alone as we have done. We may, however, remark, that the production of a heavy crop of straw in a wet season is probably, from the cause alluded to, a very dearly-purchased produce."—Vol. xii., part 1, p. 27.

"In our paper upon the growth of wheat, published in the Journal of the Royal Agricultural Society in 1847, we have attempted an estimate of the probable amount of nitrogen required to obtain a given amount of it in the increased produce. We there provisionally assumed that 5 lbs. of ammonia were required to produce an increase of one bushel of corn and its equivalent of straw. We do not intend to enter fully into the question of the accuracy of this estimate on the present occasion, but we may observe in passing, that among the plots the history of which we have given in the foregoing pages down to the last harvest, there is not one, even under the best conditions as to artificial mineral supply, where the ammonia, on the average of seasons, has given an increase equal to that supposed in our estimate. . . . .

"Without further inquiring then, into the correctness of our estimate, it would seem that a loss of this kind during the growth of the plant is a fact which is sufficiently substantiated, at once by the practical experience of the farmer, and by experiments of an independent kind relating to it. And, let it once be recognised, in agricultural science, that there is a definite expenditure or consumption of the nitrogenous bodies derived through the roots, connected with the fixation and elaboration of certain constituents of plants, and that this is greater or less according to the sources or the exact composition or state of elaboration of the products, and an important step will be gained towards a clearer conception of the principles involved in the alternation in a course of cropping, of plants of varying products and habits of growth."—Vol. xii., part 1, pp. 31, 32.

We will next show, whether or not that which we have assumed regarding the excess of nitrogen required in manure over that obtained in the increase of the cereals grown by it, was "a mere stroke of fancy," or whether it was "ascertained by a series of observations." On this subject we will bring one quotation from our former papers, and we will then adduce a summary of an immense mass of experimental evidence on the point in question. We say:—

"Thus, among from *two to three hundred experiments* with ammoniacal manures, we have in no single instance recovered in the increase the amount of nitrogen provided in the manure; and this fact is perfectly consistent with the amounts of produce found, in the experience of the farmer, to be obtained by the use of Peruvian guano and other nitrogenous manures."—*Jour. Roy. Agr. Soc. Eng.*, vol. xii., part 1, p. 29.

In the following Table (VII.) is given a summary of the amount of nitrogen recovered in the increased produce, for every hundred parts of it supplied in manure, in the cases both of barley and of wheat. It will be seen, that we have here the

results obtained under eight different conditions as regards the nature of the nitrogenous manure, its amount, or the circumstances under which it was employed, viz , whether with or without the addition of mineral manures. The number of cases brought under calculation, including both wheat and barley, amounts to nearly 300; and the number of years over which the experiments extended, was nine in the case of wheat, and three in the case of barley. The minor questions as to the influence of individual seasons, the varying proportions of corn and straw, the slightly varying percentage of nitrogen due to the combined influences of season and manure, and other points, it would, of course, be impossible to treat of, in the mere outline which we are now professing to give. With regard, however, to the varying percentage of nitrogen in the produce according to the amount of it in manure—a point to which Baron Liebig alludes—we may simply say, that it in no way materially affects the general result obtained. We may add, that the percentages of nitrogen in corn and straw respectively, employed in the calculations, are in most cases the results of direct determinations made upon mixed samples of the produce (grain and straw separately), of the several plots which go to form a single result in the Table.

TABLE VII.

Summary—Nitrogen in total increase (Corn and Straw) for 100 in Manure.
CROPS—Wheat and Barley.

General Description of Manures.	Wheat.	Barley.
1. Ammonia-salts (standard amount) alone	31·9	43·4
2. Nitrate of soda (do. do.) alone	29·3	28·4
3. Ammonia-salts (do. do.) with minerals	42·5	48·1
4. {Ammonia-salts or rape-cake} (do. do.) do.	38·3	35·5
5. Ammonia-salts (less than standard) do.	53·4	60·6
6. Nitrate of soda (do. do.) alone	52·2	42·4
7. Ammonia-salts (more than standard) with minerals ..	34·3	..
8. {Ammonia-salts or rape-cake} (do. do.) do. ..	37·2	..
Means	39·9	43·1

The results here stated may surely be considered as "ascertained by a series of observations." We have, first, the amount of nitrogen recovered in the increase of wheat and barley, when what is termed a "standard amount" of nitrogen alone, is employed; that is to say, such an amount as experience shows will yield a pretty full, but rather too heavy a crop to bear the

average of seasons. We have this amount supplied both in the form of ammonia-salts, and in that of nitrate of soda. We have it also with the admixture of minerals; and again when, besides minerals, the same amount of nitrogen is supplied indifferently in the form of rape-cake alone, or a mixture of rape-cake and ammonia-salts. We have next, in Series 5 and 6, the amount of nitrogen recovered, when *less* than the standard amount of nitrogen was employed. And lastly Series 7 and 8, when *more* than the standard amount of nitrogen was used.

Now, since *season* has a very great effect upon the amount and description of the increase obtained by nitrogenous manures, and as the whole of these series do not apply equally to the same years, it is obvious that niceties of variation cannot be discussed upon such a summary statement of results as is here given. The general fact is clear, however, that the proportion of the supplied nitrogen not recovered in the increase of crop, is, in all cases, very large. The proportion of loss is greater when the standard amount of nitrogen is used alone, than when a liberal supply of minerals is also added. But it is seen, that even when only the standard amount of nitrogen is used (an amount which does not yield more increase than should be obtained under high farming on the land in question), and when to this is added a liberal supply of mineral constituents, still there is little more than 40 per cent. of the supplied nitrogen recovered in the increased produce of corn and straw which is obtained. When, again, with the minerals, *less* than the standard amount of ammonia is employed, that is, *less than is adequate to give an amount of crop equal to that produced by good farming*,—we have, even in that case—a case which of course in practice could not be followed—little more than 50 per cent. of the supplied nitrogen recovered in the increase of crop. But when, with the mineral constituents, we add *more* than the standard amount of nitrogen, *though not more than gave a still further increment of increase*, we have little more than one-third of the nitrogen of the manure returned in the increase.

It is seen, that with both wheat and barley, a large amount of nitrogen alone, applied as nitrate of soda, gives a worse result than a large amount of salts of ammonia alone. The nitrogen applied as *rape-cake* gave, in the case of wheat, nearly an equal result with that in ammonia-salts; when used with barley, it gave considerably less return in its increase than when applied in the latter form; but the amount of rape-cake employed, was obviously far too great for the favourable maturing of the barley in the average of seasons.

As a final average it is seen that we have, including all these cases and extending over so many years, in the case of *wheat*, only 39·9 per cent., and in that of barley only 43·1 per cent., of

the nitrogen of the manure recovered in the increase of crop!—and certainly the near approximation in the averages of the two crops is not a little striking; especially when we remember, that in the case of the barley there were no instances of *more* than standard amount of nitrogen used, which would obviously have brought down its final average nearer to that of the wheat.

Now, the final average here obtained in the case of *wheat*, would represent exactly 5¼ lbs. of ammonia for each bushel of grain (with its equivalent of straw), obtained by its use, assuming average proportions of corn to straw, and of nitrogen in both: and, again, by the same method of calculation, the return of rather more than 40 per cent. of nitrogen, the result where the standard amount of ammonia with minerals was used, would be almost identically equivalent to 5 lbs. of ammonia in manure for every bushel of corn, and its equivalent of straw, obtained as increase of crop!

So much, then, for the indications of some hundreds of direct experiments on this subject. But we further unhesitatingly maintain, that the general result here arrived at, agrees very closely indeed with that of common experience in the use of guano and other nitrogenous manures for the increased growth of grain.

Consistently with the object of this paper, which is simply to meet the objections of Baron Liebig to our facts and conclusions, and to adduce, in the form of condensed summaries of our field experiments, such evidence as shall serve to establish the facts and conclusions thus disputed, it would be out of place, even did our space permit it, to enter into any detailed consideration of what may be the scientific explanation of the practical loss of nitrogen, which we have just illustrated. Hoping, however, to recur to this subject before long, we may nevertheless, in passing, state, that various experimenters have recorded an evolution of nitrogen from the leaves of growing plants, beyond that which they thought they could attribute to the atmosphere with which their plants had been supplied; but as observations of this kind have not established a clear distinction between the leguminous and the cereal plants of our rotations in this respect, further evidence is of course necessary, before we should be justified in confidently attributing the phenomenon in question, to the functional actions which have been supposed to be the source of the evolution of nitrogen from the leaves of plants, observed in the experiments alluded to. The only explanation of this practically observed loss, which has been suggested as *special to the cereals*, is that proposed by Mr. Way; namely, that the silica required by these plants, is taken up as a silicate, of which ammonia is a base; and that this alkali, or its constituents, is evolved upon the fixation of the silica by the plant. Professor

Wolff has to a great extent adopted this view; and has adduced various circumstances connected with the development of these plants, as corroborative of its probability. Baron Liebig has, on the other hand, energetically repudiated the explanation offered by Mr. Way; founding his objections on the fact, that water containing ammonia or its salts dissolves less of the alkaline silicates than does pure water itself. Experiments of this kind, made upon chemical compounds *out of the soil*, cannot be considered satisfactory as the ground of conclusions as to what would happen under the complicated conditions of cultivated soils. We have, however, found, that water containing salts of ammonia dissolved less silica than pure water, when percolated through a given bulk of soil. But the question may, after all, not so much depend upon the *amount* of the silica which will be dissolved in the soil, as upon the state of chemical combination from which it is most easily assimilated by the plant.

It has been with a view to aid the solution of the question of the varying amount and sources of the nitrogen assimilated by the different plants of our rotations, that we have, for a series of years, conducted investigations on the amount of water passing through different plants, under equal and varied conditions of growth, in relation to the quantitative fixation in them of their several constituents. The results of these investigations, as we have elsewhere pointed out, have an interesting bearing upon the phenomena we have been discussing. But so important has it appeared to us, to clear up many open questions which suggest themselves, that not long ago we induced a promising and accomplished young chemist from the laboratory of Professor Bunsen (Dr. August Pauli), to devote himself for two years to this subject, in the laboratory at Rothamsted. Unfortunately, his death, almost as soon as he had commenced his labours, prevented the further prosecution of the exact path of research then proposed; though we still hope that investigations which we have for some time had in progress, and to which we shall now direct more close attention, will enable us to record before long, further advance in our inquiry.

But there are means adopted by the farmer of increasing the growth of grain, without either the artificial supply of nitrogen to the soil, or the intervention of a fallow *crop*. These are, *bare fallow* and the *mechanical operations of the farm*. Now, as Baron Liebig has modified his views on the efficiency of these means, in his 'Principles' just published, we must take the statement of his views as given in the third and fourth editions of his main work, to show what were the views which, until lately, he advocated on this question. In these editions he gave a distinct and separate chapter on fallow and the mechanical

operations of the farm, in which is found all but the first of the following sentences; this one immediately preceding that special chapter:—

"From the preceding part of this chapter it will be seen that fallow is that period of culture when the land is exposed to progressive disintegration by the action of the weather, *for the purpose of liberating a certain quantity of alkalies and silica to be absorbed by future plants.*

"The careful and frequent working of fallow-land will accelerate and increase its disintegration: for the purposes of culture it is quite the same whether the land be covered with weeds, or with a plant which *does not extract the potash from the soil.*"—*4th Edition*, p. 127.

Speaking of the mechanical operations of the farm, he says:—

"Their action consists in accelerating the weathering or disintegration of the soil, *and thus offers to a new generation of plants their necessary mineral constituents in a form fit for reception.*"—*4th Edition*, p. 130, 131.

"We renew the surface of the soil and endeavour to make every particle of it accessible to the action of *carbonic acid and oxygen.* Thus we procure a new provision of *soluble mineral substances* which are indispensable for the nourishment and luxuriance of a new generation of plants."—*4th Edition*, p. 132.

And again:—

"Fallow, in its most extended sense, means that period of culture during which a soil is exposed to the action of the weather, for the purpose of enriching it in certain soluble ingredients. In a more confined sense, the time of fallow may be limited to the intervals in the cultivation of cereal plants; for a magazine of soluble silicates and of alkalies is an essential condition to the existence of such plants."—*4th Edition*, p. 132, 133.

"The mechanical operations of the farm, fallow, the application of lime, and the burning of clay, unite in elucidating the same scientific principle. *They are the means of accelerating the disintegration of the alkaline silicates of alumina, and of supplying to plants their necessary constituents at the commencement of a new vegetation.*"—*4th Edition*, p. 136.

Now, *fallow* would generally be applicable to land after its agricultural exhaustion by the growth of a series of crops, and as a preparation for the growth of a succeeding crop of grain—and we maintain, that in 99 out of 100 such cases, in ordinary cultivated lands, mineral manures would not adequately raise the produce, whilst the application of ammoniacal salts or nitrate of soda would certainly do so;—we cannot imagine, therefore, that the increase in produce in such a soil *by fallow*, can be measurable by the amount of mineral constituents liberated by the chemical action of the atmosphere on the soil. We fully grant, indeed, that such action—such liberation of mineral constituents—does take place during fallow; but we maintain, that there would be no adequate increase of produce, unless at the same time there were a condensation of available nitrogen from atmospheric sources within the soil itself, and that it is by the amount of this accumulation of available atmospheric food of plants *within the soil*, rather than by the amount of liberated soil-proper constituents, that the increased produce of grain will be measurable.

It should be mentioned, that in the fourth and last edition of Baron Liebig's main work, in the chapter entirely devoted to an explanation of the beneficial effects of fallow and the mechanical operations of the farm, he does not say one single word in reference to the accumulation by these means, of available atmospheric food—nitrogen—within the soil itself; but only of the greater supplies of the *mineral* or soil-proper constituents, which are thereby rendered soluble and available for the plants. We have ourselves, on more than one occasion, called attention to the former influences; and also to the fact, that a study of the properties of soils in relation to the accumulation of the atmospheric food of plants, promised to be of more value to agriculture, than that of the mere determination of their percentage composition in the *mineral food* of plants; and, to the opinion that this is a field of inquiry highly deserving of the attention of the agricultural chemist, we are happy to have *now* the sanction of Baron Liebig himself. Thus he *now* says:—

"*Fallow* is the time during which this weathering takes place. During fallow, carbonic acid and *ammonia* are conveyed to the soil by the rain and the air; the *ammonia* remains in the soil, if substances be present in due proportion which deprive it of its volatility by combining with it."—*Principles*, p. 26, prop. 26.

And again:—

"But so to prepare the *soil* as to enable *it* to extract from the air, and the other sources offered to plants by nature, and to condense in its products a *maximum of nitrogen*,—this, indeed, is a problem worthy of scientific agriculture." !—*Principles*, p. 105.

Here again, in his 26th, as well as in his 14th proposition, there is evidence that Baron Liebig's views have been strikingly "corrected and enlarged"! This influence of *fallow* is then we say, not that, there being within the soil a more liberal provision of the mineral food of plants, they, *the plants*, are enabled to absorb more nitrogen from atmospheric sources; but it is, so far as accumulation of nitrogen is concerned, that *the soil itself* has absorbed it from atmospheric sources; without which condensation within the soil, of the atmospheric food of plants, no adequate increase of produce of grain would have been obtained, however great might have been the increased supply of the *soil-proper* or *mineral* food of the plants.

Our next endeavour will be to trace the chemical statistics of an actual *rotation of crops* itself, which will enable us to form a judgment, whether the facts which are thus elicited, taken in connection with those which have been indicated with regard to the action of manures on the individual crops, do not afford us some insight into the chemical principles upon which that main arm of agriculture, *rotation*, is founded. Before, however, enter-

ing upon a consideration of our own evidence and conclusions on this point, it may be well to give a very rapid review, of what may be called the *natural history* of the various opinions which have of late years been entertained, regarding the two most important and closely allied subjects, of *manure* and *rotation*.

At the time of the appearance of Baron Liebig's first work in 1840, the prevailing impression, which had received much confirmation from the investigations of M. Boussingault, was, that *nitrogen* was one of the most important constituents of manure. Baron Liebig, in his first edition, also dwelt particularly on this point; but at the same time, he drew much more special attention to the importance of the *mineral* constituents of plants than had hitherto been bestowed upon them. After the publication of Baron Liebig's first book, M. Boussingault published much more fully the results of his various agricultural investigations, and the conclusions to which he had arrived in regard to them.

With respect to *manures*, he (M. Boussingault) concluded that their relative value was determinable, more by the amount of nitrogen they contained, than by that of any other constituent. And in reference to the subject of *rotation*, after having given the chemical statistics of three separate courses, in which roots, leguminous crops, and cereals had been alternated with each other, and also of one with wheat grown two years in succession, after fallow and manure, he thus speaks in regard to the mutual relations of different crops:—

"In the five years' rotation, it may be observed that there are two crops, the hoed crop and the forage crop, which yield substances to the ground that are both abundant in quantity and rich in azotised matter, and it is unquestionable that these crops act favourably on the cereals which succeed them. But data are wanting for the appreciation of their specific utility to the general rotation." —*Rural Economy*, p. 488.

And, again, in the next page, he says:—

"When the relative value of different systems of rotation are discussed in the way we have done, we in fact estimate the value of the elementary matter derived from the atmosphere by an aggregate of crops; but the procedure generally followed is silent when the question is to assign to each crop in particular the special share which it has had in the total profit."

Now, Baron Liebig, after detailing the experiments of M. Boussingault—in the course of which he argues, that inasmuch as a larger amount of nitrogen was obtained in some of the later crops of the rotation, than in the earlier ones which immediately succeeded the application of the manure, it was obvious, that the nitrogen of the crops could not be due to the nitrogen of the manure which had been applied—says:—

"Boussingault concludes that leguminous plants *alone* possess the power of appropriating, as food, nitrogen from the air, and that other cultivated plants do not *at all* possess this property. Hence the great importance which Bous-

singault ascribes to manures containing nitrogen, for, according to his view, the commercial value of a manure depends on its amount of nitrogen. *But all these conclusions are thoroughly erroneous; for, if they were not so, it must follow that potass, lime, and silica plants, unless they belonged to the leguminosæ, would not produce any nitrogen, unless they were supplied with manure containing that element.*"—*4th Edition*, p. 207, 208.

Baron Liebig goes on to maintain, that, owing to the method of experimenting adopted by M. Boussingault, he had obviously under-estimated the amount of nitrogen which he had supplied in the manure at the commencement of his rotations; and that, in point of fact, he had added much more of that constituent to the soil, than he had taken off in his course of crops. And, on this point, he says:—

"Hence his erroneous conclusion, that the leguminosæ alone possess the power of condensing nitrogen from the air; and that it is necessary to furnish nitrogen to the gramineæ, and to plants such as turnips and potatoes."—*4th Edition*, p. 208, 209.

Baron Liebig supports his general argument by reference to the produce of Hungary, Sicily, the vicinity of Naples, the valley of the Nile, the meadows of Holland, and of other localities; and he maintains, that the nitrogen in these cases must have been derived from the atmosphere, and not from manure. And, he asks:—

"Are the fields of Virginia, the fields of Hungary, our own cultivated plants, not able to receive it from the same sources as the wild-growing vegetation? *Is the supply of nitrogen in animal excrements a matter of absolute indifference;* OR DO WE OBTAIN IN OUR FIELDS A QUANTITY OF THE CONSTITUENTS OF THE BLOOD, ACTUALLY CORRESPONDING TO THE SUPPLY OF AMMONIA?

"*These questions are completely solved by the investigations of M. Boussingault; which are so much the more valuable, as they were instituted with a totally distinct object in view.*"—*4th Edition*, p. 205.

We could point out other sources of error in the reasoning of Baron Liebig, but we will here simply call attention to the fact, that in the amount of nitrogen (22 lbs. per acre), which he says the fields of Virginia annually yield without manure, we have the most satisfactory proof of the inapplicability of any deduction from such an instance, regarding the requirements of *our own cultivated plants*. Thus, an average crop of wheat in this country, under good cultivation, will contain twice as much nitrogen as is here supposed.

It is in reference to the facts and arguments above alluded to, that Baron Liebig concludes as follows, in the sentence which, with reference to special points, we have quoted already more than once:—

"Hence it is quite certain, that in our fields, the amount of nitrogen in the crops is *not at all in proportion to the quantity supplied in the manure*, and that the soil cannot be exhausted by the exportation of products containing nitrogen, (unless these products contain at the same time a large amount of mineral

ingredients), *because the nitrogen of vegetation is furnished by the atmosphere, and not by the soil.* Hence also we cannot augment the fertility of our fields, or their powers of production, by supplying them with manures rich in nitrogen, or with ammoniacal salts alone. *The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure.*"—*4th Edition*, p. 210.

From this short recital, the reader will be able to form a judgment, of what were the prevailing ideas, and what the points in question *regarding manure*, and therefore what was the extent of the meaning of Baron Liebig, when he wrote the sentences quoted above, and considered it so essential to attribute a *preponderating value and importance* to the *mineral* constituents of manure. And it was in reference to the conclusions arrived at by the facts and arguments above referred to, taken in connection with a consideration of the sources and mineral composition of animal excrements, that Baron Liebig in the preface to the 3rd and 4th editions of his main work (published respectively in 1843 and 1847), said :—

"And I am now, for the first time since the completion of these labours, in a situation to give a simple and determinate expression to my view of the origin of animal excrements, and of the cause of their beneficial effects on the growth of all vegetables."

To vindicate himself, however, from the imputation now made by most writers on the subject, that in these arguments and conclusions he has underrated the value and importance of nitrogen or ammonia within the soil, Baron Liebig quotes in his '*Principles*,' recently published, the following sentence, occurring in the same chapter of his work as that from which we have made the extracts given above.

"In order to obviate any misunderstanding, we must again draw attention to the fact, that this explanation is not in any way contradicted by the effects produced on the application of artificial ammonia, or of its salts. Ammonia is, and will continue to be, the source of all the nitrogen of plants; its supply is never injurious; on the contrary, it is always useful, and, for certain purposes, indispensable."—*4th Edition*, p. 212.

The above vindicatory sentence, quoted from his previous work, Baron Liebig now adduces with the following preface :—

"In order not to excite new doubts, and in order *to put an end to a misunderstanding, which I thought, but vainly, as it appears, I had rendered impossible in my work, I repeat here what I said in that work.*"—*Principles*, p. 107.

It would have been more candid if Baron Liebig had given the paragraph in question to the end; for, in what immediately succeeds to the sentences which he here brings forward, is contained the clearest proof that there has been no misunderstanding such as he here complains of.* The continuation in his work is as follows :—

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* Mr. Maskelyne also, in the 'Saturday Review' of December 15, gives the

"But, at the same time, it is of great importance for agriculture, to know with certainty that the supply of ammonia is unnecessary for most of our cultivated plants, and *that it may be even superfluous, if only the soil contain a sufficient supply of the mineral food of plants, when the ammonia required for their development will be furnished by the atmosphere. It is also of importance to know, that the rule usually adopted in France and in Germany of estimating the value of a manure according to the amount of its nitrogen, is quite fallacious, and that its value does not stand in proportion to its nitrogen.*"!

Such, then, were the reasonings and conclusions of Baron Liebig regarding the relative value of the constituents of *manure*, founded, to a great extent, upon a consideration of the experiments of M. Boussingault on the chemical statistics of *rotation*, and in opposition to the opinions arrived at by the latter in regard to those experiments. On the chemical principles involved in *rotation itself* Baron Liebig thus expresses himself:—

"In a more confined sense, the time of fallow may be limited to the interval in the cultivation of cereal plants; for a magazine of soluble silicates and of alkalies is an essential condition to the existence of such plants. The cultivation of potatoes or of turnips during the interval will not impair the fertility of the field for the cereals which are to succeed, (supposing the supply of alkalies to be sufficient for both), because the former plants do not require any of the silica necessary for the latter."—*4th Edition*, p. 133.

Again, after many pages of illustration of the importance of the *mineral*, or *soil-proper* constituents, he says:—

"It follows, then, from the preceding observations, that the advantage of the alternate system of husbandry consists in the fact that the cultivated plants abstract from the soil unequal quantities of certain nutritious matters.

"A fertile soil must contain in sufficient quantity, and in a form adapted for assimilation, all the inorganic materials indispensable for the growth of plants.

"A field artificially prepared for culture, contains a certain amount of these ingredients, and also of ammoniacal salts and decaying vegetable matter. The system of rotation adopted on such a field is, that a potash-plant (turnips or potatoes) is succeeded by a silica-plant, and the latter is followed by a lime-plant."—*4th Edition*, p. 169.

And in his 'Principles' recently published, he sums up the rationale of rotation in his 35th Proposition, thus:—

"On the unequal quantity and quality (solubility, &c.) of the mineral constituents, and on the unequal proportions in which they are required for the development of the different cultivated crops, depends the *rotation of crops*, and the varieties of rotation employed in different localities."—P. 29.

Here, then, we have distinctly enough set forth, even up to the present time, Baron Liebig's *mineral theory* of rotation; and we have already seen, that he has pronounced as "thoroughly erroneous," M. Boussingault's conclusions as to the greater dependence of the cereals grown in our rotations, upon nitrogen

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sentence *without the continuation*, to illustrate our unfairness in not fully quoting Baron Liebig!

provided in the soil, and as to the greater reliance of the leguminous crops grown in alternation with them, upon atmospheric sources of nitrogen;—and also his conclusion that the amount of produce in the rotation is in proportion to the nitrogen in the manure.

Now, if M. Boussingault really did intend to say, "that leguminous plants *alone* possess the power of appropriating, as food, nitrogen from the air, and that other cultivated plants do not at all possess this property," he certainly here committed an error; that is to say, if his meaning were, that the latter would assimilate only the amount of nitrogen conveyed to the soil *in the form of manure*, and that they would not give a certain annual average produce independently of such supply. Such an error, if it were committed, would easily arise from the fact, that in his own experiments on the growth of wheat by means of manure, in which he only recovered in the produce about as much nitrogen as the manure contained, he had not by the side of his manured plot one growing the same crop without manure. By such a collateral experiment, he would have learned how much of his total produce was due to soil and season, independently of direct manure, and how much to the latter. Had he, indeed, possessed these data, he must then have concluded, that the cereals did accumulate a limited amount of nitrogen from natural sources; and that the *increase* beyond this amount, was obtained only at a cost of much more nitrogen in the manure than was stored up in the *increase* of crop produced by it. And had M. Boussingault clearly appreciated this fact, regarding which, since the time he wrote, so much evidence has been recorded, he would scarcely, whilst so prominently calling attention to the distinctions which he observed in regard to the requirements of the cereals and leguminous plants in his rotations, nevertheless, have said, in reference to those admirable results, that they rather afforded a view of the circumstances of an entire rotation, than threw any light on the special share in rotation of the individual crops. Nor could he have failed to see, that in those distinctions which he really did point out, was the very key to the chemical principles involved in rotation of crops. M. Boussingault, indeed, distinctly called attention to the fact, that the benefits derived from growing a leguminous crop before a cereal, must to a great extent arise from the amount of organic matter thus accumulated within the soil as a manure for the latter. He further pointed out, that the very restorative leguminous crops, nevertheless take from the soil a very large proportion of some of the most important of the mineral constituents; and from the latter fact he seems to have drawn the inference that in the choice of our succession of crops, care should be taken to make the selection

with clear reference to the amount of the various mineral constituents removed from the land in the different crops. Was there not, however, we may ask, in the very facts here recorded, namely, that notwithstanding the exhaustion of minerals the clover was still so good a preparative for wheat—was there not in these coincident facts, that which would rather lead us to suppose, that the benefits arising from the order of succession merely of restorative and other crops, was little dependent on the mineral requirements of the individual crops?—and in fact, that if only the restorative crop, with its large demand for minerals, were enabled to grow luxuriantly, we might then conclude, that the soil was so rich in available mineral constituents, that the succeeding crop with its comparatively meagre demand, and to which the former is known to be so subservient by the matters it leaves behind it, was little likely to find them wanting?

Baron Liebig, however, carries the mineral explanation of rotation very much further, when he says, in regard to M. Boussingault's opinions:—

"But all these conclusions are thoroughly erroneous; *for, if they were not so, it must follow that potass, lime, and silica plants, unless they belonged to the leguminosæ*, would not produce any nitrogen, unless they were supplied with manure containing that element."—*4th Edition*, p. 208.

Nor could Baron Liebig have reasoned as he did in regard to the analysis of M. Boussingault's rotations, had he, not only dwelt more upon the composition of each individual crop and their relations to each other, but at the same time recognised that which he will not even now admit, namely, that any *increased produce* of wheat is obtained only at the cost of more nitrogen provided in the manure than is recovered in that *increased produce.*

But let us see how *the mineral theory of rotation*, as expressed in Baron Liebig's 35th Proposition, is consistent with the evidence of direct experiment.

In Table VIII. we have the chemical statistics of three actual rotations; in each of which the course consisted of Swedish turnips, barley, clover, and wheat; and in all cases the entire produce of the swedes (both leaf and bulb) was removed from the land.

In rotation 1, the course commenced without any manure at all.

In rotation 2, it commenced with a manure of superphosphate of lime alone.

And in rotation 3, with a liberal mixed manure, containing rape-cake, ammonia-salts, potash, soda, and magnesia, and superphosphate of lime.

The constituents per acre which are calculated are, dry organic matter, nitrogen, total mineral matter, and the phosphoric acid,

potash, lime, magnesia, and silica contained in the latter. The dry organic matter, nitrogen, and mineral matter, are in most cases calculated from direct determinations, made on the produce of the different plots ; but in any cases where such direct results were not attainable, the averages of allied cases have been taken. The *constituents* of ash are, however, in all cases calculated from an adopted average percentage, deduced from a consideration of all recorded analyses with which we are acquainted,* taken in connexion with the analyses of similar ashes made in the laboratory at Rothamsted :—

TABLE VIII.—Chemical Statistics of three Rotations, constituents per acre (lbs.). Entire produce of Swedes (leaves and bulbs) carted off the land.

	1848. Swedes.	1849. Barley.	1850. Clover.	1851. Wheat.
Rotation 1.—Swedes, unmanured.				
Dry organic	2460·	3872·	4325·	4315·
Nitrogen	64·	52·	142·	57·
Mineral	127·	179·	417·	217·
Phosphoric acid	14·5	21·1	31·3	24·6
Potass	33·8	31·3	83·5	33·4
Lime	19·3	12·6	125·2	11·4
Magnesia	3·3	7·2	35·5	7·2
Silica*	2·0	92·1	12·5	125·8
Rotation 2.—Swedes, by Superphosphate of Lime.				
Dry organic	3945·	2810·	4450·	4583·
Nitrogen	98·	38·	146·	60·
Mineral	228·	129·	429·	235·
Phosphoric acid	20·7	16·0	32·2	26·7
Potass	61·0	22·8	85·9	36 5
Lime	34·4	8·8	128·8	12·4
Magnesia	5·9	5·3	36·5	7·9
Silica*	3.7	65·3	12·9	137·9
Rotation 3.—Swedes, by mixed Manures.				
Dry Organic	4984·	3269·	5164·	4520·
Nitrogen	139·	45·	170·	59·
Mineral	227·	145·	498·	234·
Phosphoric acid	19·9	17·8	37·4	25·6
Potass	58·3	25·6	99·7	35·6
Lime	36·9	10·0	149·5	12·2
Magnesia	6·0	6·0	42·3	7·6
Silica*	3·7	73·8	14·9	135·6

* In some cases *sand* is obviously included with the "silica."

Now it is obvious, that if the benefits of rotation depended on the "unequal quantity and quality (solubility, &c.) of the mineral constituents, and on the unequal proportions in which they are required for the development of the different cultivated crops," and if the benefit of the clover here introduced between the cereal barley and the cereal wheat, were the less exhaustion of the minerals by the leguminous crop, we should surely find, that in the cases here given, the latter had taken out of the land less of the important mineral constituents than either the barley grown before it or the wheat which succeeded it. But what are the facts of the case? *In every case there is more—and in most cases very much more—of phosphoric acid, potash, lime, and magnesia, taken off the land in the clover crop, than in either the barley or the wheat.* And it should be remarked, that the produce of wheat obtained after the interposition and heavy mineral exhaustion of the clover, was in every case a very full one; in fact, it was such in amount that we have every reason for concluding, that it was nearly double what would have been obtained had it been grown immediately succeeding the barley. The fact is, therefore, that we have a very much larger produce of wheat after this great drain from the land of phosphoric acid, potash, lime, and magnesia, than we should have had without the intervention of the crop which extracted them. But there is one mineral constituent, namely, silica, which was taken out in very small quantity by the clover, though in very large quantity both by the preceding barley and the succeeding wheat.

If, therefore, the benefit of the intervention of the clover, depended upon its exhausting less of certain mineral constituents of the soil than the wheat which was to succeed it, it could only be in reference to *silica* that it had this beneficial action. But Baron Liebig has told us, that, provided there be a sufficiency of available alkali in the soil, there will never be a deficiency of available silica. And if this be so, since we find that in every case, the clover found in the land nearly three times as much potash as was required by the succeeding heavy crop of wheat, we can hardly attribute the benefit of the clover upon the wheat crop to its conservation of soluble silica in the soil for the latter. But further, since we know from other experiments, that immediately after the barley, we could have obtained a crop of wheat nearly, if not quite, equal to that which was obtained after the intervention of the clover, by means of ammoniacal salts, or nitrate of soda alone, it is clear that, unless the action of the latter manures was to render silica soluble and available for the crop, the beneficial action of the clover can have nothing whatever to do with the increase in the soil for the wheat crop of any of the important mineral constituents enumerated.

Taking together, then, the now established facts, that the supply of available nitrogen to a cultivated soil, greatly increases the produce of wheat,—that the clover, which has the same effect, has rendered the soil much poorer in all the important mineral constituents required by the wheat, except silica,—and that the clover again is known to yield twice or three times as much nitrogen per acre as a cereal grain when equally provided with it by manure, and that it also leaves a large amount of organic residue in the land,—have we not in these facts, sufficient ground for concluding, that the beneficial effect of the leguminous clover has been the accumulation from atmospheric sources *within the soil itself, of available nitrogen for the increased growth of the cereal grain?* And have we not in this fact, taken in connection with that of the much larger amount of nitrogen required in manure than is obtained in an increased produce of wheat obtained by its use, the clearest key to the benefits of the so-called *fallow crops* in alternation with grain? Have we not in these facts the clearest proofs, that *the rotation of crops* does *not* depend "on the unequal quantity and quality (solubility, &c.) of the mineral constituents, and on the unequal proportions in which they are required for the development of the different cultivated crops?" And how, we would ask, if an adequate increased growth of corn be only attainable by the accumulation of *available nitrogen within the soil*—and if one of the chief means of the farmer to this end were a rotation of crops, by which he is enabled "to produce manure for his corn crops, that is, for the growth of his saleable produce"—and if the great object to be attained in our time is "to substitute for a rotation of *crops* a rotation of the proper *manures*"—how, we would ask, would an adequate increase of grain be possible under such circumstances, by the supply of a *rotation of manures from without*, founded on a knowledge of the composition of the ashes of crop to be grown?!

To resume—as the result of our whole inquiry we conclude:—

1. That the manure indicated by the resultant requirements of British agriculture has no *direct connection* with the composition of the mineral substances collectively found in the ashes of the produce grown on, or exported from the farm; and that the direct mineral manures which *are* required, are not advantageously applied for the direct reproduction of the exported corn, but should be used for the green or *fallow crops*—one of whose offices it is, to collect from the atmosphere, or to conserve on the farm, *available nitrogen*, for the increased growth of the cereal grains.

2. That the nitrogen required to be provided *within the soil* for this purpose, is far greater than that contained in the increase of produce obtained by it.

3. That the chemical effects of *fallow*, in increasing the growth

of the cereal grains, are not measurable by the amount of the additional mineral food of plants liberated thereby, these being, under ordinary cultivation, in excess of the assimilable nitrogen existing in or condensed within the soil in the same period of time. The amount of the latter therefore—(*i.e.*) the *available nitrogen*—is the measure of the increased produce of grain which will be obtained.

4. That the beneficial effects of *rotation*, in increasing the production of saleable produce (so far as they are chemical), are *not* explained by the fact of one plant taking from the soil more of the different mineral constituents than another, but depend on the property of the so-called green or *fallow* crops of bringing, or conserving, upon the farm, more substance rich in nitrogen than is yielded to them in manure; whilst the crops to which they are subservient, are both largely exported from the farm, and yield in their increase considerably less nitrogen than is given to them in manure.

5. Finally—that, in the existing condition of British agriculture, a full production of the *saleable cereal grains*, with other exportable produce, is only attainable, whether by *manures*, *fallow*, *or rotation*, provided there be an accumulation of available nitrogen *within the soil itself.*

Rothamsted, *December*, 1855.

Note.—It is due to the authors of this paper to state, that in consequence of want of space, it has unavoidably been somewhat condensed.—Ed.

The foregoing article is so much more controversial in its nature than any which have hitherto appeared in the Royal Agricultural Society's Journal, that some explanation seems to be required of the circumstances which have led to its insertion. It will not be necessary on this occasion to discuss the general question, whether controversy is or is not the best mode of eliciting truth; and by limiting the following remarks to the particular case in point, it may be shown in few words, that to have declined to accept Mr. Lawes's paper because it consisted in great part of a defence of the principles embodied in his previous publications, would have been a tacit abandonment of the opinions previously advocated in this Journal, as well as a great loss to the supporters of sound agricultural science.

It will be in the recollection of all who have watched the rise and progress of this important controversy that, in the year 1840, Baron Liebig first published in this country his great work on Agricultural Chemistry. At that time a very general impression prevailed that British agriculture was capable of great develop-

ment, but that there were no established principles to guide its advance, nor even any sure ground on which to tread if any deviation were made either to the right or to the left of the beaten track marked out by our forefathers.

The appearance of Baron Liebig's book was, therefore, naturally and deservedly hailed with great delight. All admired the masterly way in which he traced the elements of vegetable life to their original sources, pointed out their chemical composition, and followed them through the various stages of the plant's development and maturity, until the process of decay had again reduced them to the elementary form. His main position too, that in order permanently to maintain the fertility of cultivated land, it was necessary to restore to it all the substances contained in the various crops exported from the farm, was as new to agriculturists as it was convincing, and its application to practical agriculture seemed as simple and easy as it has since been found to be complicated and difficult.

For the time, however, the whole secrets of the science of agriculture seemed to be laid open by the production of this master-key; nor could it well be otherwise. The accuracy of the chemical investigations which formed the basis of this work has never been questioned, and the reasoning with which the various results were united into one consistent and comprehensive scheme, seemed so sound and satisfactory, that the delighted reader was led on by easy steps until he reached an elevation from which it was difficult to avoid believing that the prospect before him included the whole *past*, *present*, and *future* of agriculture.

But however perfect the theory in the case of normal vegetation, such as that of our natural woods and plains, or when applied to the reclamation of a virgin gravel-pit, it was soon found that the teaching of Baron Liebig's work, though invaluable in its *suggestive* capacity, was yet not sufficiently matured to be of use to the practical agriculturist; and the entire failure of the numerous special or *universal* manures which appeared in rapid succession, not even excepting the one which received the sanction of the great philosopher himself, plainly proved that his various conclusions required important modifications before they could be made applicable to the artificial wants of improved agriculture. These modifications have been supplied by Baron Liebig from time to time in his later works, after personally inspecting the existing condition of practical agriculture in Great Britain. Suggestions of a totally opposite kind have been advocated by Mr. Lawes; and it is on the comparative merits of these respective adjustments that British agriculturists are now called on to decide.

But it is time that some allusion should be made to the source from which Mr. Lawes's information is chiefly derived. It was about the time of the appearance of Baron Liebig's first work that Mr. Lawes commenced his scientific course of experiments on the application of special manures to various crops, and whether we look at the number of these experiments and the length of time over which they extend, or at the great skill, untiring labour, and unstinted expense bestowed upon them, or lastly, at the immense importance of the results obtained, we shall perceive that they are altogether unequalled in this or any other country, and that they entitle Mr. Lawes to the grateful thanks of his fellow-countrymen.

What then are the main points at issue between the great chemist of Giessen and the great experimentalist of Rothamsted? In attempting a very brief answer, it must be premised that it is simply the impression left on the mind of an unscientific reader after a careful perusal of the rival statements. The leading features of the case then may be stated as follows:—Baron Liebig, in the first edition of his work on Agricultural Chemistry, points out the importance of the presence of vegetable and animal manures in the soil, in consequence of their furnishing carbon and nitrogen to the growing plant in its early stages; but in the later editions of that work, as well as in other publications, he treats the *mineral* ingredients of manure as of paramount importance, teaching that, if these latter are present in sufficient quantity and in available form, the requisite nitrogen and carbon will be obtained from atmospheric sources. The practical deduction to be drawn from these opinions is, that when endeavouring to increase the fertility of land, *the first step to be taken is to employ a manure containing an ample supply of the mineral constituents of the crops to be grown.* The most satisfactory test that can be obtained of any man's opinions is that furnished by his own practical application of them; and had any doubt existed as to the correctness of the foregoing brief statement of Baron Liebig's doctrine on this point, it would have been removed by the fact, that when a manure for wheat was brought out in this country under the name of Liebig's manure, the composition of which, there is every reason to believe, received his direct sanction, it consisted of the *mineral constituents* of the wheat crop.

On the other hand, Mr. Lawes's experiments soon convinced him that an artificial supply of *nitrogen* in the soil was generally necessary when an increased growth of corn was desired. His first paper on this subject appeared in this Journal in 1847, and the very plain indications afforded by the experiments there recorded were strongly confirmed by numerous additional facts contained in the article published in 1851, also in this Journal,

by Mr. Lawes and Dr. Gilbert. The practical inference drawn from these papers was, that in the ordinary condition of cultivated land, the *nitrogen, and not the minerals*, would generally be found deficient, and *that the first step towards improvement must therefore be to employ a highly nitrogenous manure*, especially where the growth of corn was the principal object. Hence it appears that the point in dispute, which has sometimes been represented as a mere nominal difference, is in fact fundamental, as it would, when carried out in practice, cause an improving farmer to lay out his money in the purchase of manures of totally different characters and effects, accordingly as he adopted the views of one or other of the opposing statements.

The facts and arguments contained in the accounts of Mr. Lawes's experiments were considered so conclusive by practical agriculturists, that for some years past his recommendations have been very generally acted upon, and such excellent results obtained as to produce a deep conviction of the soundness of the views on which they were founded. In fact, the scientific creed of the British farmer of the present day might almost be said to begin and end with the two axioms—that *nitrogen* is the principal desideratum in a manure for *corn*, and *phosphorus* in one for *turnips*.

These opinions are directly attacked by Baron Liebig in his 'Letters,' where, speaking of Mr. Lawes, he says, that "*It requires all the courage derived from a want of intimate acquaintance with the subject to assert that certainly ammonia is peculiarly fitted for grain, and phosphorus for turnips*," &c.; and in his last publication relating to this controversy (March, 1855), he states that Mr. Lawes has "*disproved what he intended to prove*," has "*proved what he intended to disprove*," and that he (Baron Liebig) regards Mr. Lawes's experiments "*as the most incontestable proofs in favour of that very doctrine which they were originally intended to disprove.*" After such attacks from such a man, could it be doubted that Mr. Lawes was imperatively called upon to defend in this Journal the views which he had first propounded there, and which had since so extensively modified the practice of British agriculture?

The controversial character of the article in question has now been sufficiently accounted for. With regard to its practical merits, it will be found that a highly valuable addition to our stock of agricultural facts has been made by the publication of the numerous additional experiments brought forward by Mr. Lawes to support his former views. Table IV. especially, showing the average result of numerous experiments on the characteristic action of various manures on different crops, is of first-

rate importance; and several of the other Tables, embodying as they do in small compass the results of numerous experiments in several successive seasons, may be considered the *very essence of fact*, and will be found highly interesting and instructive. Of the merits of the controversy itself, the readers of the Journal will form their own judgment; but it cannot be denied that a disputant who can appeal to the practical success of his recommendations has a great advantage over an opponent who is unable to call to his aid this most persuasive of arguments.—Ed.

Kirby Hall, January, 1856.

XXII.—*Report on the Exhibition of Live Stock at the Carlisle Meeting of the Society*, 1855. By William Simpson, 29, Savile Row.

In writing my Report as senior steward of the cattle-yard, I have, assisted by the opinions of my brother-stewards and our veterinary professor, endeavoured to arrive at as correct a conclusion as possible as to the quality and condition of the animals exhibited in the various classes.

I think it must be admitted by all persons that the Carlisle meeting was the most successful (excepting Windsor) that the Society has ever held, not only as regards the superiority of the animals exhibited, but also as regards the financial department. This is the more gratifying, because it was unexpected by most of the members of our council on account of the great distance Carlisle is situate from the south-country breeders of stock. Doubtless the very spirited and liberal prizes given by the mayor of Carlisle and the neighbouring gentry contributed greatly to the general success of the meeting.

I will now shortly allude to the various breeds of animals exhibited.

Short-horns.—The number exhibited was quite, if not more, than an average: 98 head were brought into the yard for competition, and the quality decidedly of the very best description, especially those in classes 4, 5, and 6, being for cows, in-calf heifers, and yearling heifers, the latter considered quite equal to those exhibited at Lincoln last year. In class 5 the heifers exhibited by Mr. Townley were pronounced by the judges as very superior animals.

Herefords.—Here numbers were short of an average, but I

think I may say every animal was of first-rate quality. The two bulls in classes 1 and 2 were considered, taking into consideration weight, quality, symmetry, and early maturity, the best animals ever shown.

Devons.—Here the numbers were decidedly short, but this is not to be wondered at considering the very great distance the breeders of this excellent class of cattle reside from Carlisle; this fact, however, insured all the animals sent being extraordinarily good. The show in this class we all thought was the best ever remembered; and it was observed by competent judges that if the breeders of Devon cattle would only turn their attention to increase of weight, this class of stock would run the Shorthorns and Herefords very hard.

Scotch and other Breeds.—In these classes the quality of the few animals exhibited was very bad, except the class for the Angus breed, in which Mr. M'Crumbie exhibited four very good animals both for size and quality.

Horses.—The number of animals in these classes far exceeded the average; indeed, the horses may fairly be said to have been the great attraction of the Carlisle show, especially the Clydesdale Grey exhibited in Class 1 by Mr. Phillips, and the thorough-bred horse sent by Mr. Ferguson—these two horses being considered by the judges as near perfection in their respective classes as possible. I will here observe that the arduous duties of our veterinary professor were put to the test in having no less than 128 horses most carefully to examine and report upon.

The horses in general at this show were much freer from disease than heretofore, plainly showing the importance of a careful examination of the state of the animals sent, and with-holding the prize in cases of hereditary defects.

Leicester Sheep.—The judges considered the sheep exhibited were of a fair average quality, but I do not feel called upon to draw attention to any of them as particularly striking and worthy of notice.

Short-Wool Sheep.—The numbers here were far below an average: this, however, was made up by the excellent quality of those shown; in fact, the judges stated that they had great difficulty in deciding amongst so many good animals.

Long-Wool Sheep.—The numbers were very short; but here again the quality was very good, and in some instances the weight extraordinary.

Mountain and other Sheep.—The judges seemed to consider some of the animals very superior; but not understanding the merits of these sheep, I can only remark upon them as being in some instances extraordinary-looking creatures with small bodies and enormous horns.

The Cheviots would, I am of opinion, with judicious crossing soon become very valuable for our northern districts: to warrant me in saying this, I would draw attention to those sent by Mr. Elliot, of Hindthorpe; they speak for themselves!

Pigs.—The numbers were far below an average both of the large and small breed, and a great many of them, I regret to say, much above the age stated in their certificates! It is to be hoped exhibitors will be more careful in future. I would remark, too, that in some cases the pigs were so over-fed, that they could not possibly be considered in breeding condition.

Professor Simmonds exerted himself to the utmost in this class to prevent fraud, and clearly proved the use of dentition of pigs as a test, which, if strictly adhered to, will soon stop the frauds which have been practised at agricultural shows in the pig classes. As a whole, however, the pigs may be considered as very good, though, as will be inferred from the foregoing remark, in some instances not strictly in accordance with the rules which are laid down for the several classes.

The general arrangements of the yard were as good as possible, and every facility was given to the stewards and judges to enable them to carry out their various duties. In the horse classes four judges were appointed at Carlisle instead of three; and it is strongly recommended by the judges, my brother-stewards, and myself, that this may be the case in future, it having been found to work well—having two judges for heavy and two for light horses, and, in case of dispute, then either party can call in one of the remaining two; by this means the business was so quickly disposed of, that the award for horses was made before twelve o'clock, instead of its being the last award delivered, and the public in consequence excluded from the yard till nearly two o'clock on the day of opening.

It occurs to me, and I venture to suggest, that the stewards should remain in office six years instead of three, as is now the practice, and for this reason—it takes some time to understand the work required, and as soon as a steward is thoroughly master of what he has to do, his time expires, and a new unpractised man takes his place; if the time were extended to six years, as I have suggested, there would always be two of the stewards thoroughly understanding the work required at their hands.

XXIII.—*Report on the Exhibition and Trial of Implements at the Carlisle Meeting.* By WILLIAM FISHER HOBBS, Senior Steward.

THE agricultural implements and machinery exhibited at the Carlisle meeting, although numbering not more than two-thirds of those exhibited at recent meetings of the Society, were remarkable for their general excellence of workmanship, and in many respects novelty of construction. The trials were made with great labour and exactness, but in some cases with too strict an attention to special conditions: they were arranged according to the following programme:—

YARD.

		Judges.
STEAM-ENGINES.	2 *Prizes.*—PORTABLE STEAM-ENGINES. 2 *Prizes.*—FIXED Ditto ditto.	Mr. GOOCH. Mr. OWEN.
BARN-WORKS.	*Prize.*—PORTABLE THRASHING MACHINES. *Prize.*—Ditto ditto ditto (combined). *Prize.*—FIXED THRASHING MACHINES (combined) *Prize.*—CORN DRESSING MACHINES. Barley Hummellers. Horse Power Works. Straw Shakers, &c.	Mr. CALDWELL. Mr. BLACKETT.
MILLS, CHAFF-CUTTERS, &c.	*Prize.*—GRINDING MILLS. *Prize.*—LINSEED AND CORN CRUSHERS. *Prize.*—CHAFF CUTTERS (Horse or Steam). *Prize.*—Ditto ditto (Hand). *Prize.*—OIL CAKE BREAKERS. *Prize.*—BONE MILLS. Gorse Bruisers, &c.	Mr. NALDER. Mr. CLARKE.
MISCELLANEOUS IMPLEMENTS.	*Prize.*—TILE AND PIPE MACHINES. *Prize.*—TURNIP CUTTER. *Prize.*—ROOT PULPING MACHINES. *Prize.*—CHURNS. Brick Machines. Carts and Waggons. Cheese Presses. Draining and other Tools. Fencing & Gates, &c. Flax Machinery. Harness. Pumps. Garden Implements. Glass Utensils. Stable Fittings. Saw Tables. Root Washers. Weighing Machines. Rick Stands, and— Various unenumerated articles.	Mr. ROWLEY. Mr. FURNISS.

FIELD.

PLOUGHS, CULTIVATORS, &c.	*Prize*—PLOUGHS (for general purposes). *Prize.*—Ditto (for deep Ploughing). *Prize.*—CULTIVATORS, GRUBBERS, or SCARIFIERS. Clod Crushers. Harrows. Rollers. Subsoils. Digging Machines. Pressers. Dynamometers. Whippletrees, &c.	Mr. SCOTT. Mr. HUSKINSON.

		Judges.
Drills, &c. ..	*Prize.*—Drills (for general purposes). *Prize.*—Ditto (Corn and Seed). *Prize.*—Ditto (small occupations, Corn). *Prize.*—Ditto (ditto ditto, Seed and Manure). *Prize.*—Ditto (Turnip on flat). *Prize.*—Ditto (ditto on ridge). *Prize.*—Liquid or Water Drills. *Prize.*—Manure Distributors. *Prize.*—Horse Hoes (on flat). *Prize.*—Ditto ditto (for setting out Turnips). Horse Rakes. Sowing Machines. Seed Depositors, &c. Haymaking Machines.	Mr. Granger. Mr. Sewell Read.
Steam Cultivators	.. ..	Mr. Gooch, Mr. Owen, Mr. Scott, Mr. Huskinson, Mr. Grainger, and Mr. Read.
Reaping Machines	.. ..	Mr. Scott, Mr. Huskinson, Mr. Grainger, and Mr. Read.

Remarks on the Trials.

Steam-Engines.—The conditions of competition laid down by the Society for portable steam-engines have unfortunately led to the production of engines only intended for winning the Society's prizes, and known as "racing" engines, requiring the nicest care, instead of those simple and effective engines which may be safely entrusted to the management of intelligent farm-servants. This result has, I fear, arisen from too strict an attention being paid to the condition relating to the economy of fuel, without a corresponding regard being had to the general character and usefulness of the engine. I think it will be absolutely necessary in future for the Society not only to make such conditions in reference to the construction and trial of portable steam-engines as may prevent a recurrence of this evil, but to secure the Society and the public from disappointment in their practical value by submitting the prize-engines to subsequent trials, for a lengthened period, under the ordinary management of a farm-establishment.

Barn-works.—To the great satisfaction of the farmers, a decided improvement was this year found to have taken place in the thrashing-machines, of which the details will be found in the subjoined Report of the Judges. These machines are now become of national importance, inasmuch as they enable the farmer in so short a time to prepare the corn for market. They have, in fact, almost entirely superseded the flail; and without their powerful aid the full supplies of corn could not this autumn have been

furnished for consumption. The extraordinary demand for the thrashing-machine, and its daily use on the farm, are circumstances that prove its estimation by the agricultural community. It has, indeed, become to the farmer an object of as great importance as the plough, and accordingly has a claim on the part of the Society for every exertion being made to render it as perfect as possible. The prize thrashing-machines also require, like the steam-engines, to be placed for a lengthened subsequent period in the hands of practical intelligent farmers, before the confirmation of the awards made to them at the country meetings.

Corn-dressing Machines.—These machines are now a necessary adjunct to the thrashing-machines, and although the competition in this class was very great, and proved that some novelty of idea and construction had been introduced at Carlisle, there is, in my opinion, still hope for further improvement, and I trust the Society will not lose sight of the opening which there yet seems to be for such improvement in those at present indispensable machines.

Root-pulping Machines.—The Society, by offering a prize for these machines, has brought out several attempts towards the attainment of this object, which, although not yet fully accomplished, by the perfect pulping of the roots, has already to a certain extent been gained. These machines have been of great advantage in enabling the farmer to economize his roots ; and in a season of deficiency of the turnip-crop, like the present, they will enable him to appreciate the efforts of the Society in promoting improvement in an instrument of so much value on the farm.

Ploughs.—Although no decided practical results in the comparative draught of ploughs could be obtained, in consequence of the dynamometer employed on that occasion not being of modern construction, or satisfactory in its principle, still enough was indicated at the trials to show that improvements had taken place in the formation and arrangements of the different parts of the plough ; and although it is the opinion of many persons that perfection is really attained in this important farm-implement, yet I still look forward to the time when its construction will be better adapted to the present operations on the soil, and for leaving the land in a fit state for drills or other machines required to complete its cultivation.

Cultivators.—The cultivators, grubbers, and scarifiers require more time, and at a different period of the year, for their satisfactory trial. They evidently admit of being brought to a greater state of perfection than they have at present attained.

Rollers.—Although great improvements have been made within the last few years in these important implements, especially in rollers for pulverizing the soil, the necessity for a good roller for

corn-crops in spring was never more visible than during the last season, when much injury was done in the pulverization of the soil by the smooth-cylinder roller, used at times when Crosskill's would have been unsuitable.

Drills.—To the casual observer little or no improvement might appear to have been made in drills; still it was evident, on closer observation, that internal arrangements had been adopted for effecting greater regularity in depositing the seed and manure. I think it must also be now evident that the combined corn and seed manure-drill for general purposes may be superseded with great advantage by two distinct drills of lighter draught.

Liquid-Manure and Water Drills.—The public are not at present, I think, sufficiently acquainted with the great advantage of these drills for root-crops. Their value will, in my opinion, become every year more manifest.

Manure-Distributors.—Great disappointment was expressed at Carlisle that all the improved manure-distributors were not entered for exhibition on that occasion, as their comparison with each other would have led to interesting results. I hope that such deficiency will not be found next year at Chelmsford, for these machines have by no means arrived at a state of perfection.

Horse-Hoes.—These are implements which must always be of great use to the farmer in the eradication of weeds. No one could travel northwards to Carlisle without seeing the necessity of the substitution of some machine for the manual labour hitherto employed for setting out turnips. In Norfolk and elsewhere this operation is beginning to be accomplished by the revolving horse-hoe. I regret, however, that this implement was not exhibited at Carlisle under the most favourable circumstances of its construction. By its revolving principle the plants and soil attached are thrown up together, but the soil by its greater weight reaches the ground before the plant, which, lying bare with its roots exposed on the surface, soon withers away. This implement will, no doubt, eventually become a favourite implement with the best farmers under a perfect system of drill-husbandry.

Steam-Cultivators.—No satisfactory attempt appeared at Carlisle to carry out the much sought-for application of steam-power to the cultivation of the soil: it is evident, however, that the minds of mechanicians have been extensively turned to the subject. The time is probably not far distant when mechanical invention may yet produce a machine fulfilling the Society's condition, viz. that it shall "in the most efficient manner *turn the soil*, and be an economical substitute for the plough or the spade."

Reaping-Machines.—It is always necessary to have extended trials of reaping-machines at a proper season for thoroughly testing their respective merits when the corn is fit for harvest. These trials have this year been carried out most effectually, through the liberality of our President, at Abbot's Leigh, near Bristol; and they have proved the progress already made in that yet imperfect but very important agricultural machine. Its completeness, I fear, is only to be effected by the combination in a single machine of those principles of construction in which different parties, under the present patent-law, claim individual right. The Archimedian platform (with side-delivery), forming part of the first-prize reaping-machine of Messrs. Burgess and Key, is a decided improvement. The machine exhibited had been badly manufactured, but I am glad to learn that their machines will in future be made by manufacturers of established reputation.

Reports of the Judges.

Steam-Engines.

We have the pleasure to report the results of the trials made by us of steam-engines at the meeting of the Society held at Carlisle in July last, which were as follows:—

Portable Engines.

Name.	Stand.	Art.	Price.	Horse-power.	Getting up Steam.			Coals burnt per Hour when doing the Work.	Coals burnt per Horse-power per Hour.	
					Wood.	Coal.	Time.			
			£.		lbs.	lbs.	min.			
Tuxford .	61	1	250	Eight.	24	28	t6	29·584	3·698	First Prize.
Clayton .	31	3	260	Eight.	24	18¼	44½	32·432	4·054	Second Prize.
Barrett .	30	2	215	Six.	18	18¼	65	26·526	4·421	Highly commended
Hornsby .	26	1	255	Eight.	24	34½	39	38·712	4·839	Do.
Ransomes	95	59	230	Seven.	21	26¾	55¼	35·388	5·054	Do.
Garrett .	19	17	235	Seven.	21	26	44	39·242	5·606	Do.
Crosskill .	23	33	220	Six.	18	30	66	48·480	8·080	Commended.
Lee . .	92	1	180	Seven.	21	35	43¼	70·000	10·000	Do.

The first prize for these, it will be seen, we awarded to Messrs. Tuxford and Sons, of Boston; the consumption of fuel during the trial was most favourable, while the workmanship and price were satisfactory.

To Messrs. Clayton and Shuttleworth, of Lincoln, we awarded the second Prize, being second in consumption of fuel, while the arrangement and workmanship were equally satisfactory.

We highly commended those by Messrs. Barrett, Exall, and Co., of Reading; Messrs. Hornsby and Son, of Grantham; Messrs. Ransome and Sims, of Ipswich; and Messrs. Garrett and Son, of Leiston, as being economical in their working, and of good workmanship and arrangements.

We commended those by Alfred Crosskill, of Beverley, and Joseph Lee, of Stounall, as being useful plain engines.

We think it fair to state that the four last-named were not fitted with expansive valves.

Fixed Engines.

Name.	Stand.	Art.	Price.	Horse-power.	Coals burnt per Hour when doing its Work.	Coals burnt per Horse per Hour.	
			£.				
Ransomes . . .	95	56	195	Eight.	49·200	6·150	First Prize.
Barrett	30	3	200	Eight.	55·896	6·987	Second Prize.
Clayton	31	5	215	Eight.	54·024	6·753	Highly commended.
Tuxford	61	4	175	Six.	47·562	7·927	Commended.
Dray	34	1	240	Eight.	76·864	9·608	
Smith and Son . .	81	1	133	Eight.	94·672	11·834	
E. and B. Johnson .	75	3	110	Four.	64·812	16·203	
J. Gray and Son . .	88	1	175	Eight.	Could not keep up steam.		

To Messrs. Ransome and Sims, of Ipswich, we awarded the first Prize, the consumption of fuel being the least, while the arrangement of the engine was very simple, and the workmanship very good.

To Messrs. Barrett, Exall, and Co., of Reading, we awarded the second Prize. Although this engine was not quite so low in its consumption of fuel as that by Messrs. Clayton and Shuttleworth, yet the price being considerably lower, and the arrangement more simple by the absence of a separate expansive valve, we considered it more suitable to the objects of the Society.

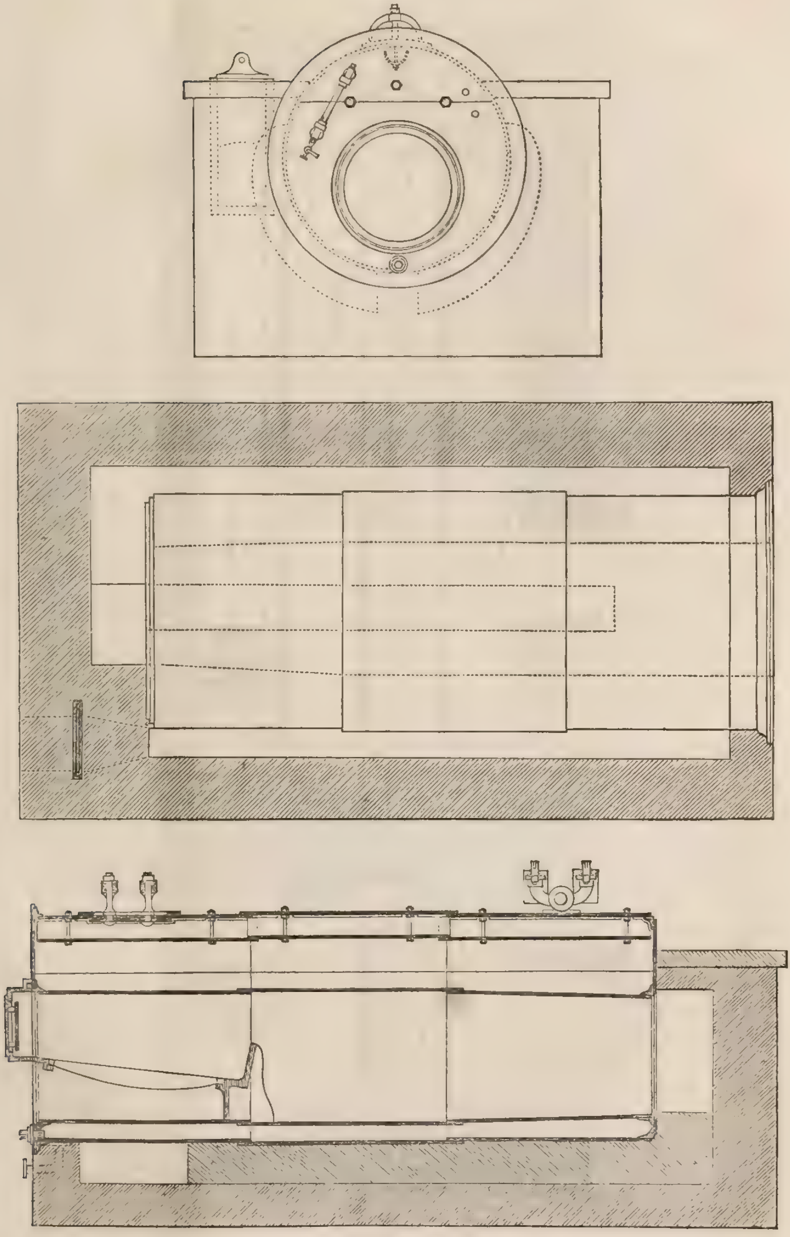
We highly commended that by Messrs. Clayton and Shuttleworth, of Lincoln; the consumption of fuel was very favourable and the workmanship very good. This engine was fitted with separate expansive valve.

We commended that by Messrs. Tuxford and Son, of Boston, the consumption of fuel being satisfactory and the workmanship good.

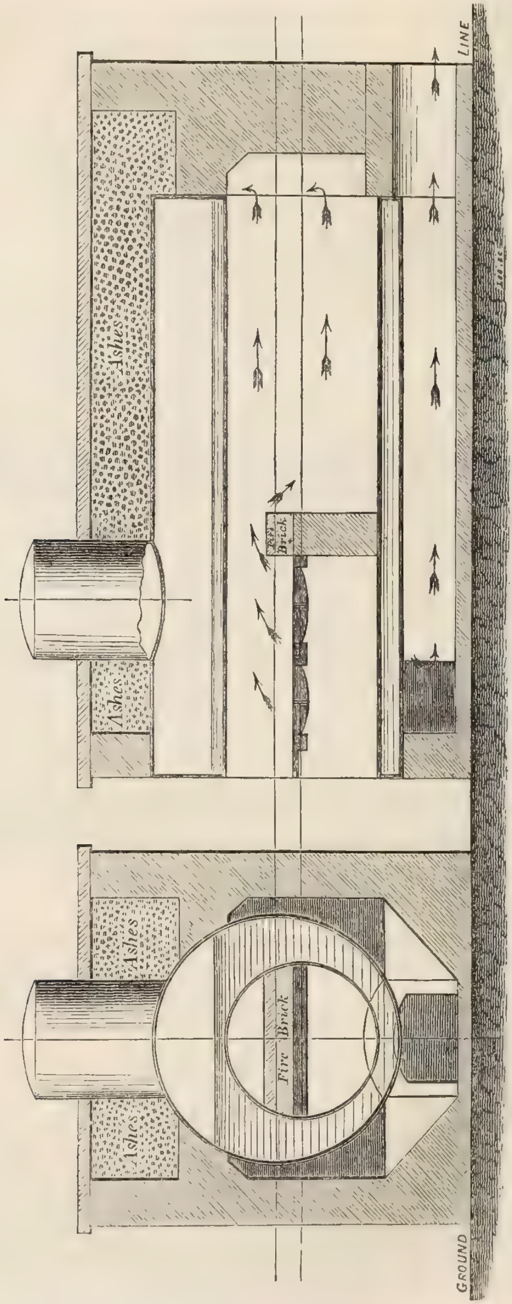
We have much pleasure in stating that throughout all the engines which were exhibited for trial there was on this occasion much less difference in the general points affecting the objects of the Society than on any former occasion. We were also glad to find that the absence of the separate and additional expansive valve has not been attended with any appreciable disadvantage in the economy of the engine, while it has simplified its construction very considerably; we are thereby the more strongly induced to suggest for the consideration of the Society the desirableness that the simplicity of the engine should form one of the principal tests of merit on future occasions, regard being had to the class of persons in whose hands they are placed to work and repair.

Wm. Owen.
John V. Gooch.

An Eight-Horse Power Horizontal Fixed Steam Engine; invented, improved, and manufactured by the exhibitors. The construction of this engine is extremely simple, the various parts easy of access, and the whole fixed to the bed plate. The cylinder is $8\frac{1}{4}$ inches diameter; the length of stroke 14 inches. The crank shaft is made of the best scrap iron, 3 inches diameter; the number of revolutions will be from 100 to 120 per minute. The diameter of the fly-wheel is 5 feet 6 inches, and 6 inches wide, and answers the purpose of a driving pulley; its weight is 8 cwt. The boiler, which is a Cornish one, is 12 feet long, and 4 feet 8 inches diameter, with a flue 2 feet 9 inches diameter; the boiler has also a steam chest, 2 feet diameter, and the same height. The whole is made of the best Pontypool tin-plate iron, $\frac{3}{8}$ths thick, and riveted together by $\frac{5}{8}$ths rivets, 2 inches apart. It is supplied with a safety valve and Salter's spring balance, glass water gauge, pet cocks, blow-off cock, fire door, damper, man hole, and fire bars complete. Price, including boiler, net 200*l*. each; without boiler, 112*l*.



Scale, $\frac{3}{10}$ of an inch to a foot.



Scale, $\frac{3}{10}$ of an inch to a foot.

A Ransome's Improved Horizontal Direct-action Eight-horse Power Fixed Steam Engine; invented and manufactured by the exhibitors. Received at the Royal Agricultural Society's meeting at Lewes, 1852, the prize of 10*l.*; at Gloucester, 1853, was commended; at Lincoln, 1854, received first prize. The boiler is 11 ft. long, 4 ft. diameter, having a flue 2 ft. 3 in. diameter. The plates best Staffordshire ⅜ in. thick; rivets 1⅞ in. from centre to centre, and 11-16ths in. diameter. Diameter of cylinder 8 in., length of stroke 17½ in.; crank-shaft makes 110 revolutions per minute, and is of wrought-iron, 3 in. diameter at the bearings. The fly-wheel is 6 ft. diameter, 5½ in. wide, and weighs 14 cwt. 2 qrs., and is used as a driving-drum. The price of this engine and boiler includes all the necessary fittings and foundation-bolts, but not the connecting pipes between the engine and boiler, the cost of which varies according to their relative positions. This engine, with improvements since added, is similar to that which received the first prize of the Royal Agricultural Society of England at Lincoln in 1854. Price 195*l.*

PORTABLE THRASHING MACHINES, not exceeding Six-horse Power.

Perfect Work represented by . . .					20	15	15	12	8	70	
Name of Exhibitor.	Nominal Horse-power.	Real Horse-power.	Time in Minutes Thrashing 75 Sheaves of Wheat.	Horse-power consumed in 1 Minute.	Clean Thrashed.	Clean Shaken.	Chafings free from Corn.	Corn Unbroken.	Straw Unbroken.	Comparative Merit.	Price. £. s. d.
Ransome and Sims . . .	5	5·8	8·33	48·32	20	14	15	11	8	68	60 0 0
Garrett	4	5·07	6·75	38·5	20	..	..	11	6	37	61 0 0
Hornsby	4	6·15	6·06	37·3	20	..	..	12	6	38	65 0 0
Whitehead	4	6·45	5·16	34·42	10	..	..	..	..	..	44 0 0

The last of these three machines were tried with only 60 sheaves, and the Judges considered that they required too much power for four horses, so gave the prize to a very good machine of Messrs. Ransome, driven by steam, with Brinsmead's shaker and Worby's separators attached.

The Judges were most agreeably surprised with the great improvement in this branch of agricultural machines. The steadiness with which they worked and performed what they were represented to be capable of doing, has much exceeded the performance of other years; but we are sorry to add that the combination required to do such good work causes such an increase of weight in the machine, that they almost cease to be portable, as few of them could be moved over fields and farm-roads with less than four horses, the generality of them weighing from 2½ to 3 tons. To compensate for this weight, they ought to dress the corn for market, which cannot be done without some contrivance to make the feeding quite regular, especially in portable machines; so that the Judges quite coincide with the Society's regulations, viz. "with shaker, riddle, and winnower." They must, however, compliment Messrs. Clayton for their machine, and for the adaptation of the revolving screen patented by Mr. J. H. Nalder and Mr. Knapp. We highly commended the machine, and gave a medal for the screen, but the power required for the whole machine was too great for the prize. We gave the prize to Mr. Hornsby, the work done by his machine being very perfect, rotatory motion being applied wherever possible except as regards his shaker, and his riddle was as clean when it left off work as when it began. We highly commended the machines of Messrs. Tuxford and Humphries, the former for an excellent sample, the latter for very good sample, and we also took the price and weight

PORTABLE THRASHING MACHINES, not exceeding Eight-horse Power, with Shaker, Riddle, and Winnower, that will best prepare the Corn for the finishing Dressing-Machine: to be driven by Steam.

Name of Exhibitor.	Nominal Horse-power.	Real Horse-power.	Time in Minutes Thrashing 130 Sheaves of Wheat.	Horse-power Consumed, if Thrashed in 1 Minute.	Clean Thrashed.	Clean Shaken.	Chafings free from Corn.	Chaff free from Corn.	Corn Unbroken.	Straw Unbroken.	Comparative Merit.	Price. £.	s.	d.
Perfect Work represented by . . .					20	15	15	15	12	8	85			
Garrett	6	6·725	14·30	96·16	20	14	15	15	8	6	78	104	0	0
Humphries	6	6·38	21·32	136·0	20	14	13	12	12	7	78	80	0	0
Barrett and Exall . .	7	6·89	18·23	125·78	20	12	15	..	12	7	66	105	0	0
Holmes	7	9·18	11·83	108·72	20	12	14	15	12	5	78	115	0	0
Clayton and Co. . .	7	9·32	14·46	134·13	20	14	15	15	12	7	83	115	0	0
Tuxford	6	8·8	17·1	150·5	20	15	15	15	10	6	81	95	0	0
Ransome and Sims . .	6	6·94	18·6	129·8	20	10	15	15	10	7	77	85	0	0
Clayton and Co. . . .	7	8·50	12·2	103·7	20	14	15	15	12	8	84	95	0	0
Hornsby and Son . .	7	7·27	22·61	164·4	20	15	15	15	12	8	85	100	0	0
Trial with 100 Sheaves of Barley.														
Garrett	6	6·26	5·73	35·87	20	14	11	15	12	8	80	104	0	0
Humphries	6	6·52	8·43	54·96	20	14	15	14	12	8	83	80	0	0
Barrett and Exall . .	7	5·27	14·	73·9	20	14	15	..	12	8	69	105	0	0
Holmes			Barley Hummeller Choked.											
Clayton and Co. . .	7	7·7	6·33	48·77	20	14	15	15	12	8	84	115	0	0
Tuxford	6	6·64	9·38	62·31	20	15	15	15	12	8	85	95	0	0
Ransome and Sims .	6	6·18	7·15	48·3	20	10	12	12	12	8	74	85	0	0
Clayton and Co. . .	7	5·73	9·41	53·9	20	15	14	15	12	8	83	95	0	0
Hornsby and Son . .	7	6·73	7·58	51·1	20	15	15	15	12	8	85	100	0	0

of this machine into consideration. Messrs. Ransome and Sims' machine, from having Brinsmead's shaker attached, was steady as possible: the above Tables will point out what we consider faults; but it was really portable, and the price moderate. The Judges think highly of Messrs. Garrett's arrangement of driving the drum and other working parts from an intermediate shaft fixed on one end of the machine, doing away with much irregular wear on the drum-shaft. The greatest improvement we observed was the very slight or no breakage or nibbing of the barley. More attention is required with the shakers, as all carried over more or less grain, except those of Messrs. Hornsby and Tuxford, from neither of which could a single grain be found.

FIXED THRASHING MACHINES.

The fixed machines were very good, those of Messrs. Clayton and Garrett making most excellent samples, to the former of which we gave the Prize, highly commending Mr. Garrett's, and giving him a medal for his improved barley hummeller. We should mention that the cause of the great difference in power required between Clayton's and Garrett's machines while thrashing wheat was the fact of the former passing the wheat through the hummeller while the latter did not. The greatest space required for fixing either of these machines was a square of 20 feet, which could be reduced. Messrs. Ransome and Sims' machine did not require so much room, and was very compact.

Perfect Work represented by . . .				20	15	15	15	12	8	85	
Name of Exhibitor.	**Horse-power used.**	**Horse-power for 1 Minute.**	**Time Thrashing 130 Sheaves of Wheat.**	**Clean Thrashed.**	**Clean Shaken.**	**Chafings free from Corn.**	**Chaff free from Corn.**	**Corn Unbroken.**	**Straw Unbroken.**	**Comparative Merit.**	**Price.**
			Min.								£. s. d.
Clayton and Co. . . .	7·27	165·14	22·716	20	15	15	15	12	6	83	150 0 0
Garrett	4·8	113·9	23·73	20	14	13	15	12	6	80	147 0 0
Ransome and Sims . . .	4·63	90·384	19·5	20	14	14	15	12	6	81	150 0 0

Trial with 100 Sheaves of Barley.

Clayton and Co. . . .	7·3	64·75	8·865	20	15	15	15	12	6	83	
Garrett	7·36	72·4	9·83	20	15	10	15	12	6	78	
Ransome and Sims . . .	4·11	35·0	8·30	15	12	13	14	12	6	72	

Corn Dressing Machines.

With these machines we had great competition, but so many of them had wrong-sized pulleys on them, the makers not knowing the size of pulley on the testing-machine, that many of the trials were unsatisfactory to the Judges. We gave the prize to Messrs. Hornsby, and commended Mr. Nicholson's and Mr. Garrett's.

Trial with 31 Turns of Testing Machines.

Name of Exhibitor.	**Weight on Lever Empty.**	**Weight on Lever Working.**	**Length of Crank.**	**Best Grain.**	**Tail Corn.**	**Whites.**	**Screenings.**	**Quantity of Grain Supplied.**	**Height of Feeding Box.**	**Revolutions.**	**Time.**	**Price.**
	lbs.	lbs.	in.	st. lbs.	lbs. oz.	lbs. oz.	lbs. oz.		ft. in.		m. s.	£. s.
Boby . . .	3530	4133	12	11 1½	20 5	0 1	7 5	3	4 2¼	210	6 2	15 0
Holmes . .	4085	4340	13½	11 3½	16 8	3 10	3 1	3	4 7	53	1 7	13 13
Garrett . .	4010	4608	12	11 9½	6 1	1 9	0 9	3	4 4	52	1 6	12 0
Burgess & Key	4260	4640	12	11	15 5	2 12	8 13	3	4 7	97	3 1	10 0
Richardson .	1400	5230	12	11 3	10 9	..	1 14	3	5 0	123	3 9	6 10
Hornsby . .	4040	4403	14	13 2¼	1 11	0 11	7 15	3	4 8	22¾	0 73	11 10
Nicholson .	2770	4790	12	12 9	1 3	0 1	..	3	4 4½	58	1 8	8 8
Smith . . .	4230	4891	13	12 7	4 15	..	1 15	3	4 6	76½	2 4	10 10
Bunting . .	1525	1650	10½	13 8	0 14	0 8½	..	3	4 11	115	3 7	7 0
Caborn . .	2490	4235	12	13 3	3 10	..	0 8	3	4 8	38½	1 2	14 0

A patent grain and seed separator, shown by Dray and Co., invented by G. Salmon, of Illinois, we consider likely to throw a new light on dressing-machines; its performance in the hands of its inventors was wonderful, but it must be seen to be appreciated. We awarded it a Medal.

Hunt's clover-seed drawer had a Silver Medal awarded to it. The Judges think clover-seed ought to be provided by the Society, for want of which there was no trial, but the above award was sanctioned by one of the stewards of the yard.

We cannot close this Report without recommending the Society to furnish themselves with another testing-machine, ranging between those used for trial of thrashing-machines and hand-power machines.

H. B. Caldwell.
William Blackett.

Mills, &c.

Being fully aware that little else is required from us than a simple detail of facts connected with the trial of implements committed to our charge as judges, we proceed at once to give them, reserving to ourselves the privilege of making such remarks and observations as occurred to us during the trial, and such suggestions as we deem useful and desirable in promoting the progressive improvement of those implements with which we had to deal, and the quicker despatch of the various duties devolving upon the judges and engineers.

Our duties commenced with the trial of the implements committed to us, which were—

- Grinding-mills, steam power.
- Linseed and Oat crushers, steam power.
- Chaff-cutters, steam power.
- Chaff-cutters, hand power.
- Oil-cake breakers, steam power.
- Bone-mills, steam power.
- Gorse-bruisers.
- Malt-mills.
- Mill-dressers.
- Mill-stones, &c.

We took the Chaff-cutters, steam and hand power, first; those entered for competition we give, with their results, in tabular form annexed:—

Chaff-cutters—Power Machines.

Names of Exhibitors.	Stand.	Article.	Units of Power lifted 1 foot high.	Lbs. of Chaff cut.	Time.	Units of Power to cut 1 lb. of Chaff equal lbs. lifted 1 foot high.	Lbs. of Chaff cut per Hour.	Price.	Observations.
					min.			£. s.	
Barrett, Exall, & Co.	30	8	79,075	32½	2	2433	975	15 0	Commended.
Williams . . .	32	8	85,640	36	2	2378	980	14 14	
Dray & Co. . . .	34	16	82,526	44	2	1875	1320	13 13	Highly Commended.
Richmond & Chandler	1	3	82,440	39	..	2114	1170	10 0	Commended.
Smith & Ashby . .	20	7	71,880	28	..	2567	840	10 10	
Carson	25	1	60,990	30	..	2033	900	12 12	
Turner	47	8	58,810	20¼	..	2868	615	11 11	
Cornes	70	1	89,720	49½	..	1812	1485	13 0	Prize.
Ransome & Sims .	95	31	25,340	20	..	1267	600	10 0	
Garrett & Son . .	19	23	98,290	39¼	..	2446	1185	15 0	Commended.

Observations.—Barrett and Exall's machine worked satisfactorily, and its various working parts well arranged; the three knives work on the fly-wheel, and are convex; and are thrown out of work by a single movement from the right (front) side, drawing back the shaft-wheel, which grasps the clutch by which they are turned. Williams's machine worked indifferently; clogged in feeding. Dray and Co.'s machine worked irregularly at first, but finished well. The cut is regulated by two large wheels of different diameters, and is thrown out of work by a simple movement withdrawing the pinion from these wheels; feeding-rollers deeply grooved. Richmond and Chandler's machine fed rather roughly at top; kept a full box, and did its work well; has two knives; rollers for feeding made with curved teeth. Smith and Ashby's has the simplest action, and has three convex knives of 24 in. cutting-edge, and cuts fairly and feeds well. Carson's machine made very excellent work, but at too much expense in power to drive it; it has three concave knives, driven by a clutch arrangement, simple and good; a bevel-wheel with clutch also regulates the feed. Turner's machine fed fairly, but thin, and not well pressed at the top; it has two large convex knives; the feeding arrangement rather complicated. Cornes' machine fills easily and feeds regularly; by additional

rollers (which may be dispensed with if required), it cuts admirably and with unusual ease; it is readily thrown out of work by a rod, on which are two mitre-wheels, by the clutch being withdrawn; the moveable roller in front is a great acquisition; the cutting-edge of the three convex knives 22 in. each. Ransome and Sims' machine was hurriedly set to work, and cut indifferently; the feeding is regulated by an irregular cam driving a steel wheel to lift the ratchet to let in the feed, which it holds firmly till cut; calculated for either horse or steam power. Garrett and Son's machine works well, and cuts fast; the cut is regulated by a shifting clutch on the shaft of the fly-wheel; the feeding by two large rollers; no adjustment to throw it out of work.

Chaff-cutters—Hand-power Machines.

Names.	Stand.	Article.	Units of Power in lbs. lifted 1 foot high.	Lbs. of Chaff cut.	Time.	Lbs. per Hour.	Units of Power required to cut 1 lb. of Chaff in lbs. lifted 1 foot high.	Price.	Observations.
					min.			£. s.	
Crosskill	23	40	..	6	4	90	3310	7 0	
Garrett & Son . .	19	24	20,200	8½	4	127½	2376	4 10	
Williams	32	7	14,420	6½	4	97½	2218	6 10	
Hill & Smith . .	37	23	14,300	7½	..	112½	1907	5 0	Commended.
Smith & Ashby . .	20	8	15,580	9	..	135	1731	5 10	Highly Commended.
Richmond & Chandler	1	2	16,100	12½	..	187½	1288	7 0	Prize.
Cornes	70	6	14,530	10	..	150	1453	4 10	Highly Commended.
Carson	25	2	31,760	11	..	165	2887	5 10	
Ransome & Sims .	95	32	17,980	14	..	210	1284	4 15	

Observations.—Crosskill's machine cut fairly, but clogged in feeding, owing to its awkwardly-curved toothed feeding rollers. Garrett and Son's machine feeds and cuts well, but rather long; it has three knives, and is worked by a spiral screw movement. Williams's machine: this worked fairly, but not very satisfactorily; similar in construction to the power-machine. Hill and Smith's machine went through its trial well, and made good work; it is an attempted improvement upon Cornes' machine; and, so far as putting the working parts behind the cutting ones, it is so; the two knives are short; the feeding arrangement good. Smith and Ashby's machine made good work; cut its chaff easily, and with great regularity; it has two convex knives, with long cutting edges, and is worked by very simple movements; is very compact in all its arrangements. Richmond and Chandler's worked admirably, cutting a large quantity of chaff with great facility; the working parts are well got up; has two large knives; the feeding is by curved-toothed rollers, and the front is large and elevating; it will cut various lengths by an easy mode of alteration. Cornes' machine worked very well; it made rather too coarse a sample; it is fitted with two long-edged knives, and its working parts well made, and very compact; of similar construction to his power machine: the price is a very great recommendation, 4*l.* 10*s.* Carson's machine made the best work during the trial, but at great expenditure of power; it is worked by a spiral screw; the two knives have long cutting edges, and the feeding rollers are deeply grooved, and fed with great regularity. Ransome and Sims' machine: too much was attempted, and made coarse chaff; feeds well; has two long concave knives; the feeding-rollers are fluted.

Steam-power Cake Breakers.

Hornsby's machine made very satisfactory work, and capable of doing much of it; the series of breakers are separate castings, cast iron and chilled; the

adjustment for altering the size very good, only the replacement of a wheel does it; breaks any size, and screens it. Garrett and Son's machine made very satisfactory work, breaking the cake for sheep well: it is a well got up machine, and can be made to break cake to any size. Crosskill's machine made good work, but is rather smaller than the above machines, and can be worked either by hand or horse power.

Name.	For Sheep.					For Cattle.				Observations.
	Stand.	Article.	Time breaking 14 lbs. Linseed Cake.	Units of Power used.	Lbs. of Cake broken per Hour.	Time breaking 14 lbs. of Cake.	Units of Power used.	Lbs. of Cake broken per Hour.	Price.	
			Sec.			Sec.			£. s.	
Hornsby .	26	8	14	4280	3600	10¾	2710	4692	10 0	Highly Commended.
Garrett . .	19	22	19¼	5130	2618	14	1960	3600	11 0	Prize.
Crosskill .	23	37	14¾	5540	3435	1[illegible]¼	2990	3809	7 10	Commended.

Cake-breakers, Hand Power.

Smith and Ashby's machine worked very satisfactorily; the frame with two sectional parts, by which it is easily taken to pieces: the crushing-rollers are also in two pieces; it is made to break different sizes by reversing the action of the handle. Hornsby's machine worked very satisfactorily. Ransome and Sims' machine worked very well: the cake was broken fine, but not so easily as the other machines. Samuelson's machine worked satisfactorily, and broke the cake with less dust. Nicholson's machine worked well.

Linseed and Corn Crushers.

Name.	Stand.	Article.	Time crushing 14 lbs. of Linseed.	Units of Power used.	Quantity crushed per Hour.	Time bruising 7 lbs. Oats.	Units of Power used.	Quantity bruised per Hour.	Price.	Observations.
			Sec.			Sec.			£. s.	
Turner .	47	1	55·2	42,900	950	29·3	30,510	860	11 11	Prize.
Stanley .	46	1	55·4	54,000	909	44·8	26,640	585	11 11	Highly Commended.
Ransomes	95	24	111·4	33,760	452	92·2	20,250	273	10 10	
J. Woods	41	8	103·3	72,410	487	45·8	22,410	549	11 11	Commended.

Turner's machine worked with great satisfaction, and crushed a large quantity well in the time: it is the well-known crusher from which most other improvements in crushing emanated, having the two large and small rollers working in contact with each other; both were well crushed—linseed second best, oats best crushed. Stanley's crusher worked well, and kept up its reputation; both linseed and oats were well crushed, and not over-done; it runs by straps and grooved wheels, and has a lever in front to regulate the feed. Ransome and Sims' machine did not crush well, owing to some error in the adjustment; both linseed and oats were not well done: it is, however, deserving of especial notice for its mechanical contrivances; two small wheels of about 16 in. diameter crush against each other; it has two hoppers for linseed and oats and beans respectively: the latter it will crush at the same time it may be crushing linseed or oats: what we, however, wish to name more particularly is the casting of the barrel; best steel blades are modelled in sand at equal distances, the metal is poured in, the iron is filed away,

leaving the edge of the steel blade for grinding purposes. Phillips and Wood's crusher made very good work, crushing the linseed best, oats second best, but took too long time in doing its work; the large crushing-wheel is 4 ft. diameter, working against a small one.

Grinding Mills.

Competitors' Names.	Stand.	Article.	Time in Minutes.	Quantity ground in lbs.	Horse-power consumed in grinding 5 Minutes.	Bushels ground per Horse-power per Hour.	Price.	Observations.
							£.	
Whitmee and Co.	21	10	5	..	..	..	52	
Hayes	11	1	5	33¼	8·46	·95	26	Highly Commended.
Clayton and Co.	31	11	5	27¼	7·62	·86	48	Prize.
Crosskill	23	34	5	25¼	5·29	1·15	55	Commended.
Turner	47	7	5	21¼	7·22	·714	25	

The barley used in these trials weighed 50 lbs. to the bushel.

Whitmee and Co.'s grinding-mill was withdrawn, owing to a miscalculation of speed by which it was to be driven. Hayes's mill worked well; the meal soft: it is fitted with Derbyshire Peak stones. Clayton, Shuttleworth, and Co.'s mill worked with great steadiness and regularity, and made a good sample of soft meal; its feeding arrangement is very good, being a toothed disk upon a vertical spindle, allowing the most minute adjustment to regulate the degree of fineness of meal required. Turner's mill worked fairly, but not so well as either of the above; the sample of meal coarser: it is upon a somewhat new principle; the corn first passes between two smooth metallic rollers, by which it is crushed before reaching the stones; it is then ground in the usual manner. Crosskill's mill: the sample of meal from this mill was not fine, owing to its not being properly set to work.

Bone-mills, Steam Power.

Crosskill's well-known mill was the only one in competition; it was not tried, not having bones at hand; but as its character was known, and being the same as last year, we had no hesitation in awarding the prize. This machine grinds by means of iron plates, which revolve in contact. Motion is given to the lower plate, and the upper one is carried round by the friction of the substance grinding; it will grind bones to powder, or minerals if required.

Gorse-bruisers, Malt-mills, Mill-dressers, and Mill-stones.

We did not see a gorse-bruiser. We tried one or two malt-mills, but observed nothing new or worthy of commendation. The mill shown by Whitehead we most approved. Mill-stone dresser: this is a small implement, with pick attached, worked by hand; it is well adapted for use. Mr. James showed a pair of red freestone mill-stones: we hesitated to commend them, not knowing their capabilities or durability.

In concluding our Report, we cannot speak too much in praise of the valuable improvements introduced by Mr. Amos into his "Testing-machine," or of the ability, manner, and industry he displays in conducting these trials.

James Hall Nalder.
Jno. Clarke.

Miscellaneous Articles.

The show of machines, implements, and other articles of a miscellaneous character in the yard, both useful and ornamental, was, as usual, extensive and various. The Meeting at Carlisle was most successful in this department, and will most likely show a favourable comparison with the Meetings held at Lincoln and Gloucester. And there can be no doubt that the character of the articles exhibited has been greatly improved the last few years. Many that were useless in practice have disappeared altogether, while others have been so changed as scarcely to be recognised. This is as it should be. The exhibitors themselves are the first to benefit by attending the Society's Meetings, where they compare their implements and machines with others of rival manufacture. It would be nearly impossible for the Judges to notice in their Report the multitude of things exhibited for which no premiums are offered; but they endeavoured, as far as time permitted, to examine everything that came before them as to their economy and usefulness, and their general adaptation to agricultural affairs.

The machines that came on first for trial were the turnip cutting and pulping machines. In the former very little change is made, excepting some improvement in the working parts.

The following is the tabular statement:—

Root-cutters for Sheep.

Names of Exhibitors.	Stand.	Art.	Price.	Weight of Turnips in lbs.	Registered Power required to do it.	Revolutions.	Awards.
			£. s.				
Carsons (Moody)	25	3	4 10	40	5,750	34¼	Highly Commended.
Fowler and Fry	35	7	4 0	40	10,590	53	
Keely	103	3	6 6	40	7,445	52	
Samuelson (Compound	64	2	5 10	40	2,865	22¼	Ox-cutter. } The
Machine)	64	2	5 10	40	4,446	30	Sheep-cutter. } Premium.
Forshaw and Co. (Compound	72	9	5 15	40	5,780	34¼	Sheep-cutter.
pound Machine	72	9	5 15	40	3,495	19¼	Ox cutter.
Richmond and Chandler	1	14	4 10	40	9,490	62	
Ransome & Sims (Com-	95	39	5 10	40	6,500	37½	Sheep-cutter.
pound Machine)	48	39	5 10	40	4,240	30	Ox-cutter.
Bernhard and Bishop	48	75	4 10	40	6,860	36½	Commended.

The prize was given to Samuelson, whose machine worked very easy and maintained its reputation. It required less power, but cut the pieces larger, than the others. Both Carsons' and Bernhard's machine did their work in a very proper manner, cutting the turnips into thin slices, so that chaff or meal might be incorporated, and possessing in some degree the rare merit of separating the dirt.

Hand-pulping Machines for Beasts or Sheep.

It is a question what degree of pulp is intended, and whether a perfect pulp is desirable.

The nutritious properties of a turnip are not increased by either cutting or pulping. But the latter process enables the turnip to be incorporated with other material, as before mentioned. In this case the more nearly the turnip is reduced to a pulp, the more perfectly that result will be attained. But in this highly-reduced pulp there is a partial separation of the liquid and solid portions of the turnip. Should any of the saccharine of the turnip be carried away in the liquid and lost, which would be the case without great care, this new process might be attended with disadvantages. It may be objected, too, that sheep can pulp the turnip themselves with the teeth nature has provided

them; but the experience of last winter, where sheep were eating frozen turnips for many weeks, shows the utility of this aid to difficult mastication.

Names of Exhibitors.	Stand.	Art.	Price.	Weight of Turnips cut in lbs.	Registered Power required to do it.	Revolutions.	Award.
			£. s.				
Samuelson . . .	64	9	4 10	40	15,630	59$\frac{1}{4}$	
Bernhard and Bishop	48	74	4 10	40	38,250	208$\frac{1}{4}$	
Phillips	41	1	6 10	40	45,230	128$\frac{1}{4}$	The Premium.
Keely and Co. . .	103	2	6 6	40	79,570	392	
Power-pulping Machines for Beasts or Sheep.							
Garretts	19	25	8 8	80	80,080	280	Highly Commended.
Phillips	41	5	12 12	80	51,190	103	

Drain Tile or Pipe making Machines.

In this trial there were three competitors—Messrs. Scragg, Whitehead, and Williams. The clay was unsuitable for the trial, being full of small stones or flints, and the screening difficult.

Names of Exhibitors.	Stand.	Art.	Length of Pipe.	Number of Pipes.	Comparative Power.	Price.	Awards.
						£. s.	
Scragg	8	1	13$\frac{1}{2}$	197$\frac{4}{13}$	27,830	17 0	Highly Commended.
Whitehead . . .	65	2	13$\frac{1}{2}$	197$\frac{6}{13}$	27,250	21 0	The Premium.
Williams	32	10	Withdrawn.				

This trial reversed the decision at Lincoln. The tabular statement shows how nearly the machines were matched. Whitehead's machine had some advantage over the other in screening; and on this account, more than from any great superiority in making tiles, received the premium. Mr. Williams's machine contains a new principle that may, when perfect in its details, be of considerable advantage.

Churns.

Names of Exhibitors.	Stand.	Art.	Quantity of Cream in Quarts.	Time in producing Butter in Minutes.	Quantity of Butter in lbs.	Price.	Awards.
					lbs. oz.	£. s.	
Tinkler	5	1	16	12	13 4	4 0	Commended.
Greening	6	31	16	32	7 7	9 15	
Gilkerson . . .	18	1	12	14	9 9	3 15	
Dray and Co. . .	34	55	4	17	3 8	2 5	Highly Commended.
Burgess and Key .	68	14	4	19	3 13	2 0	Premium.

In this trial the candidates found the cream to suit the dimensions of the churn. The whole was mixed together, and each received their allotted quantity. It is evident from this trial that proportionately more butter is produced from a small quantity of cream. This is an old doctrine, and there

is less liability to sweating in churning 10 quarts of cream than 20. Is it, then, desirable to have large churns?

A Silver Medal was awarded to William Pearce, Stand 42, Article 3, for "a patent spring shaft car or chaise cart." This article is novel, and though without steel springs, travelled on the road easily and lightly, carrying six passengers. For family purposes it seems well adapted, but whether the principle applied to the shafts will be made available for farming purposes, is a question not yet solved. The car is a comfortable and unique vehicle.

Mr. James Boydell, Stand 85, Article 2, exhibited a cart having attached to it an endless railway. This curious adaptation of a railway attached to the wheels of the cart by segments was also applied to a locomotive engine in the yard, which astonished all who witnessed its performance. On soft and deep sandy roads, where heavy weights have to be moved at a slow pace, the principle may have some advantages. But bad roads are now the exception, and we leave the consideration of this new principle in the hands of our mechanical engineers.

J. Jephson Rowley.
Lawrence Furniss.

Trial of Field Implements.

Report on Ploughs.

Two prizes were offered by the Society in this department, viz.:—

1. For the plough best adapted for general purposes.
2. For the plough best adapted for ploughing more than 9 inches deep.

Ploughs for General Purposes.—Eleven ploughs were selected for trial in this class, of which seven were from Cumberland and the neighbourhood, chiefly "swing" ploughs, or ploughs without wheels, belonging to Messrs. Brayton, Dalton, Hope, Hackness, Morley, Robinson, and Sewell; the remaining four were iron *wheel* ploughs belonging to Messrs. Ball, Busby, Howards, and Ransomes and Sims.

The trials took place in a field of seeds pastured; a rather strong loamy soil, with a considerable quantity of herbage upon it, and therefore well adapted for testing the merits of the ploughs, particularly in the most important parts of the operation—that of skimming or paring, depositing, and so effectually covering turf and surface weeds, as to prevent subsequent vegetation.

The directions were for each plough to commence with a furrow of 9 inches by 5, to be subsequently increased to 10 inches by 7. It was soon very obvious, even in the shallow ploughing, that the local "*swing*" ploughs had not a chance of success against the *wheel* ploughs. The Judges therefore discontinued further trials as to these, and the competition at the increased depth was continued with the ploughs of Messrs. Ball, Busby, Howard, and Ransome only.

The work by all these ploughs was excellent, and such as fully to sustain the reputation of their makers; the competition between the ploughs of Messrs. Howard and Ransome was particularly close, and their merits so evenly balanced that the Judges had some difficulty in their decision. In the hope of doing full justice to these eminent competitors, the Judges determined to submit the following Table of results as a means of showing the comparative amount of merit, more clearly and accurately than could be done by mere description.

The quality of the work, in the opinion of the Judges, has never been exceeded; the furrow was cut with great clearness, regularity of depth, and uniform inclination, and the well formed skim-coulters, with chains and weights attached, pared off, and deposited the turf, with a precision and completeness that left nothing to be desired.

Exhibitors' Names.	Stand.	Art.	Dimensions of Furrow-slice.	Force of Traction.	Angle of Land-side.	Angle at which the Furrow is laid.	Evenness of Sole, 15.	Uniformity of Furrow-slice, 20.	Turf well Deposited, 10.	Amount of Merit.	Price.
			Inches.	Cwt.	°	° ′					£. s.
Howard .	91	2	10 × 7	4·75	88	117 36	12	18	10	40	4 10
Ball . .	62	1	10¼× 7	5·50	90	117 0	9	14	9	32	4 8
Busby . .	49	7	10 × 7	5·00	88	117 36	12	16	8	36	4 4
Ransome .	95	1	10 × 7	4·75	91	116 42	15	18	10	43	4 5

The Judges awarded the prize to Messrs. Ransome and Sims, highly commended Messrs. Howards' plough, and gave a well-earned commendation to those of Mr. Busby and Mr. Ball.

Ploughs best Adapted for Ploughing more than 9 *inches deep.*—The field for this trial was one of seeds pastured, with considerable herbage remaining, the soil a deep and free working loam.

Five ploughs competed for this prize; the names of the competitors and the results are given in the subjoined Table.

The instructions were, that after going six times round the ridge set out, three furrows should be drawn *ten* inches deep. Although the Judges consider such depth in heavy clay soils generally impracticable, it was in these trials easily attained, and even exceeded, and at this great depth the furrow-slice was cut as clearly, and deposited with as much regularity as at the shallower depth.

The work of the entire class, with the exception of Mr. Sewell's swing plough, was admirably done, but the contest was most severe between Messrs. Busby and Ransome, and so excellent was the performance of both these ploughs that for some time the Judges were in great doubt as to their decision; towards the close of the trial Messrs. Ransome amazed every spectator by ploughing a series of well laid furrows to the full depth of 12 inches, and to Messrs. Ransome and Sims the prize was awarded. The following is the result of the trials:—

Exhibitors' Names.	Stand.	Art.	Dimensions of Furrow-slice.	Angle of Land-side.	Evenness of Sole, 15.	Uniformity of Furrow-slice, 20.	Turf well Deposited, 10.	Total Merit.	Price.
				°					£. s.
Ransome . .	95	6	15 × 10	90	15	20	10	45	5 15
Howard . . .	81	3	15 × 10	94	12	12	8	32	6 0
Busby . . .	49	6	15 × 10	92	15	18	8	41	4 15
Ball	62	2	15 × 10	90	10	10	6	26	5 8
Sewell . . .	12	2	14 × 9	72	4	6	..	10	4 10

Upon the whole the Judges are of opinion that the ploughing in these experiments was, irrespective of its greater depth, decidedly superior to what has been seen at any former Meeting of the Society; that the results demonstrate the great superiority of the iron wheel ploughs with long mouldboards, over the swing ploughs and short mouldboards still extensively used in many parts of the kingdom; and that these apparently simple implements, consisting of but few parts, and those of no great complexity, have mainly by the instrumentality of the Society attained a degree of improvement and efficiency, which a few years ago was by many thought improbable, and of which too many are yet ignorant.

Those who have carefully observed and compared the progressive im-

provement of these implements at the successive Meetings of the Society, will not look to the past without satisfaction, nor to the future without hope.

For the best Cultivator, Grubber, and Scarifier, a Prize of 5*l.*

Three implements were put in competition for this prize, viz.:—

Mr. Bentall's "Broadshare Plough," Mr. Coleman's "Cultivator," and Messrs. Ransome's "Biddel's Wrought Iron Scarifier."

They were all first tried with *broad shares* upon a piece of pastured seeds, as paring ploughs, and though the ground was hard and dry, and in a state more unfavourable than any farmer would select for the use of such implements, the paring was well done, and proved that for paring stubble-ground they were all very effective implements. The second trial was with *points*, instead of shares, in cross-dragging seed land that had been once ploughed. The Judges were of opinion that for paring turf or stubbles only Mr. Bentall's implement deserved the high reputation it has obtained; and as a cultivator for very strong lands, where great power was necessary, the implement of Messrs. Ransome would be most effective; but as an implement combining the qualifications of cultivator, grubber, and scarifier, which seems to have been the object of the Society in offering the prize, Mr. Coleman's was preferred, and to him the prize was awarded.

The Judges highly commend Mr. Bentall's implement as a scarifier, and commend Messrs. Ransome's as a grubber, scarifier, and cultivator.

Mr. Hope's Plough.—This plough was submitted for trial by the exhibitor as possessing an improvement over ordinary ploughs in having a bevel wheel attached, following in the furrow, by which the draught was said to be greatly lessened.

The plough was tested by the Dynamometer with and without the wheel, and it did not appear that the wheel effected any saving in draught.

Cotgreave's Plough.—This implement, manufactured by Messrs. Ransome and Sims, was first exhibited at the Society's meeting at Lincoln; on this occasion it was tried upon a field of seeds, the soil a strong and deep loam, with results that surprised and gratified all who saw it.

The operation is threefold; a furrow of 5 inches deep is first ploughed and turned in the ordinary way; a second or trench furrow is then cut 5 inches deep, inverted, and deposited on the top of the first, and at the bottom of the trench a sub-pulverizer loosens the soil to a further depth of 3½ inches; the effect of the whole upon a tolerably free soil is not only to plough and invert the land to a great depth, but thoroughly to pulverize it; no trenching or double digging by manual labour could have done more than was done by this implement, and for preparing for planting or for root crops it is of great value. No prize being offered, the Judges awarded to this implement a silver medal.

Clod Crushers.—A medal was awarded to John Palmer of Stockton, for his "Patterson's Self-cleaning Clodcrusher;" the adaptation of a series of eccentrics upon the centre axle, which, in revolving, rub and clean each other, is very ingenious and an important improvement.

A medal was also awarded to Mr. Crosskill for his self-cleaning clod crusher, which it is now impossible to choke under the most unfavourable circumstances.

A *Beauclerk's Patent Plough and Subsoiler*, exhibited by Messrs. Ransome, was submitted to trial. Its operation is that of a common plough with an Archimedian screw attached, which revolves in the bottom of the furrow, thus ploughing and subsoiling at the same time. It did not appear to the Judges to possess any special merit; there was no excellence in the result, and no apparent economy in the means; the operation of the subsoiler seemed to be detrimental to the free action of the plough, and imperfect and unsightly work was the result. Wherever subsoiling is desirable it would

in our opinion be done more effectually, and at least as economically, by a plough and subpulverizer being used as distinct implements.

Harrows.—These implements were tried upon ridge-and-furrow lands. The harrows made by Messrs. Howard, jointed near the ends, were admirably adapted for these inequalities of surface, and made excellent work. Those exhibited by Mr. Williams and Mr. Bentall were well constructed, but more particularly adapted to work on level surfaces.

There being no prize offered, the Judges highly commend the harrows of Messrs. Howard.

Steam Cultivators.

Several novel implements were exhibited in this class, but as none of them fulfilled, or made any near approach to the fulfilment of, the terms on which the Society's prize of 200*l.* was offered, the prize was withheld.

The cultivator exhibited by Mr. Usher of Edinburgh was constructed on the principle of combining the locomotive and cultivating power in one machine. It consisted of a steam engine moving itself by the revolution of a large circular roller placed under the engine; and a number of ordinary ploughshares reversed, revolving behind the engines, were the instruments of cultivation.

The Judges were desirous of testing this machine in the trial field, but the owner was either unwilling or unable to move it there, and it was therefore by permission of the local authorities of Carlisle tried upon a flat piece of rich turf land, on a deep loamy soil, near the show-yard. The results were very unsatisfactory.

The machine, under the most favourable circumstances, could with difficulty move itself, and the revolving shares neither inverted nor pulverized the soil, but tumbled it about in wild confusion, and left it in a state more unfavourable for cultivation than it was before.

The Steam Cultivator of Mr. Fiskin consisted of two ordinary ploughs fixed to a carriage or frame-work of iron, and moved by a drag rope, and an endless rope, running at great speed, communicating the power from a locomotive engine fixed in a corner of the field.

The mode of traction, communicated from a stationary engine, appeared to the Judges to recognise the only principle on which at present steam can be applied to field culture, and the application in this case was very ingenious. The machine itself, however, had been hastily constructed, and the ploughs attached were so ill formed that the work was imperfectly done, and the machine failed to give the satisfaction that would have resulted, had more time and care been given to its construction.

Though the Judges cannot report this machine in its present form as an economical substitute for the ordinary plough, they consider it an implement of considerable promise, and would suggest to the owners that in their efforts for improving it, they should avail themselves of the best form of shares and mould-boards now in use, and that provision should be made for raising and lowering the framework on either side of the machine, in order to regulate the depth of the ploughs, and to fit it for work on unlevel as well as level ground.

THOMAS HUSKINSON.
THOMAS SCOTT.

REPORT ON REAPING MACHINES.

The trial of Reaping Machines at Carlisle appeared to excite the same lively interest observable on the occasion of former experiments; and the desire of so large a number of agriculturists to witness the performance of these

machines attests in the strongest manner the importance attached to their improvement, and the necessity which is felt for so valuable an auxiliary to the labours of the harvest.

Six machines were submitted for trial; and a thin standing crop of unripe rye, upon a small area of ground, was the only means at the command of the Society at the time for testing the relative merits of the respective machines.

It was felt by the judges that experiments upon so limited a scale, which were finished in a few minutes, and confined to a crop so unlike those to which reapers must in practice be applied, was unworthy of the importance of the subject, and such as could not justify the judges in making any award. Mr. Fisher Hobbs, the senior steward, concurred in these opinions, and having represented them to the President of the Society, directed that the Judges should select such of the machines as they deemed best, and reserve them for a further trial upon Mr. Miles's estate, at Leigh Court, near Bristol.

The following machines were selected :—

Bell's improved machine, exhibited by Crosskill, price 42*l.*

McCormick's machine, improved by Lord Kinnaird, and exhibited by J. Burry, price 31*l.* 10*s.*

Hussey's reaping machine, improved and exhibited by Dray and Co., price 25*l.*

McCormick's reaper, improved and exhibited by Burgess and Key, price 35*l.* 15*s.*

Forbush and Co.'s reaper, improved and exhibited by John Palmer, of Stockton, price 30*l.*

Trials at Leigh Court.

The trial of reapers was resumed at Leigh Court on the 29th of August. Two fields of wheat, the one a moderately-light standing crop, on level ground, without furrows—the other a heavy crop, partly on uneven ground, and partially lodged, in which there were occasional patches of grass and weeds; and a field of barley, with a full crop just ripe for cutting, partly standing and partly lodged,—were the fields appropriated for trial.

An ample supply of horse power and manual labour for working the machines, and every provision and facility which could be given for ensuring a satisfactory and conclusive trial, were provided by the liberality of Mr. Miles.

Under these favourable circumstances, and in the finest of weather, the trials were conducted ; and from morning till night each machine was successively tried in cutting both wheat and barley, in light standing crops, and in heavy and lodged ones, in clean stubbles and in foul, and under circumstances as varied as an extensive farm could supply, and such as left no difficulty in appreciating the respective merits of the several machines.

As most of these machines have been exhibited at former meetings of the Society, and as they retain very much the same principles of construction and arrangement of parts which they have had for the last three or four years, it seems unnecessary to enter into a minute description of their details ; the Judges deem it sufficient to note what appeared to them the special merits and drawbacks of each machine, and the grounds on which the prizes of the Society were finally awarded.

Crosskill's machine, invented by Bell, showed great power of cutting corn, whether standing or partially laid, and takes the large breadth of 5 feet 9 inches ; did not seem liable to choke ; has great advantage in cutting backwards and forwards, and requiring no scythe-man to prepare its way ; the side delivery is equal to any other machine, and certainly superior to the best workmanship of the scythe, but the endless web appeared liable to become *disordered.* The objections are—its heavy cumbrous character, occasioning

excessive draught, and too high speed in the horses. The steerage is also very laborious, and does not give ample control over the machine. The machine requires two men to manage it; and it is the most expensive machine exhibited.

McCormick's machine, improved by Lord Kinnaird, and exhibited by Burry. —This machine cuts a space of 5 feet 6 inches, delivers in a swathe at the side by means of an endless web similar to Crosskill's, but lighter of draught. Its power of cutting is, however, greatly inferior; and in cutting barley it frequently choked. The machine is weakly constructed, and throughout the trials was the least successful machine exhibited.

Hussey's machine, improved and exhibited by Wm. Dray and Co.—This machine is described as capable of cutting a space of 5 feet 4 inches, but in the trials seldom took more than 3 feet 6 inches. The merits of the machine are its extreme compactness, simplicity of arrangement, and economy of price. It cuts standing corn very effectively; but having no collecting-reel, cannot cut corn leaning in the direction in which the machine advances. The corn, by a tilting platform, is easily delivered in a neatly-formed sheaf in the *rear* of the machine, but requires removal before the machine can return. In reaping wheat this does not appear so objectionable, but in barley and oats it is disadvantageous, because these crops do not always require binding, and will seldom admit of binding immediately after cutting. The draught of the machine is heavy, not so much from the weight of the machine as from the speed required to prevent choking. It appeared to the Judges, that if the length of stroke of the knife, which is now only 3 inches, was increased to 5 inches, the cutting power would be improved, and the speed of the machine might be reduced; at present, unless the horses move at a speed exceeding three miles per hour, which is distressing to farm-horses at such work, the cutting is imperfect. If these alterations were made, and a side delivery could be added, this would become a most valuable machine. Even in its present condition, the Judges had great pleasure in highly commending it.

McCormick's reaper, improved and exhibited by Burgess and Key.—This machine cuts a clear track of 5 feet 6 inches; and in every operation in which it was tested exhibited a decided superiority. It cut with great precision both wheat and barley, standing and partially lodged; and in cutting through weeds and grass, showed no tendency to choke; the delivery is peculiar to this machine, and is the principal and most important improvement effected since last year; the corn, on being cut, falls on a series of rollers, fitted with Archimedian screws, by which it is delivered in a continuous and well-formed swathe at the side of the machine. This delivery being effected by the machine dispenses with the attendant necessary in Dray's and Palmer's machines; and it was proved to be capable of cutting wheat and barley with no other attendance than a boy strong enough to drive a pair of horses. The draught also was much lighter than any other machine; and the horses were not required to travel faster, or to exert greater power, than would be necessary in ploughing in land of medium strength.

The superiority in cutting in this machine appeared to be the result of a larger stroke in the knife, equal to $5\frac{1}{2}$ inches; and the reduction in draught and speed the consequence of a more correct calculation and distribution of power.

The Judges had no hesitation in awarding to this machine the Society's first prize of 30*l.*; and they feel assured that all who witnessed the trials will concur in that decision.

Forbush and Co.'s reaper, improved and exhibited by John Palmer.—This machine has a cutting space of 4 feet 6 inches. In its compactness, portability, and general arrangement, it is very similar to Dray's machine; the peculiar difference is in the delivery, which in this machine is two-fold;

either in the rear of the machine, as in Dray's, or by attaching a radiating platform the corn is delivered at the side; the delivery requires an attendant upon the machine in addition to the driver. Although this side delivery has the advantage over Dray's machine of not requiring the corn to be moved, it is yet far from perfect; for, being pushed off by a rake, the corn falls neither in swathe nor well-formed sheaf, but often in a tumbled mass not very fit for binding. Irrespective of the delivery, this machine appeared to have an equality, and not more than an equality, of merit compared with Dray's machine; but the Judges considered that an arrangement which effected a side delivery, though imperfect, was of great importance, and, therefore, awarded to this machine the Society's second prize of 20*l.*

As regards the economical use of reapers, the comparison must be made with the cost of mowing; for every machine yet exhibited (Dray's excepted) is strictly a *mowing*, and not a *reaping*, machine. It is doubtless a great point gained, to have the power of cutting corn by machinery, at a time so important and critical as harvest, though the money cost may not be less: and this is specially the case now, with the increasing cost and scarcity of labour.

It is certain that nearly all the reapers in these trials are capable of cutting and delivering ordinary crops of corn at least as perfectly as the mower's scythe; and it is the opinion of the Judges that the reaper exhibited by Messrs. Burgess and Key will do this at less cost; but admitting this at present to be doubtful, all experience shows that almost every operation which can be done at all by machinery will be done more accurately and economically than by hand labour; and to this rule it is believed reaping-machines will prove no exception.

Though much yet remains to be done in perfecting these machines, it is satisfactory to the Judges to report that considerable advance has been made since last year; and they believe that ere long a reaping machine will be produced capable of satisfying every requirement.

The Judges cannot close this Report without expressing their obligations and thanks to Mr. Miles for the great facilities afforded by him for the trials of these machines, and for his obliging kindness and consideration to themselves and to all engaged in the experiments.

THOS. HUSKINSON.
CLARE SEWELL READ.

On looking back through my period of office to its commencement at Lewes, in 1852, I think the Society has reason to congratulate itself upon the steady improvements in agricultural implements and machinery which have year by year continued to mark its progress; and upon having this year at Carlisle, in a remote district of its operations, so interesting a show in that department. This advancement can only be accounted for by the competition which the Society's trials at the country meetings have excited. The agricultural mind is scarcely yet in a position to discriminate between the claims of competing machinery, or to form a satisfactory judgment on its practical value for farm purposes. The trials of agricultural machinery should be more adapted to the ordinary work required of the several machines employed on the farm, and the judges ought in every case to be men of great practical experience and independence of mind. At the conclusion of the Carlisle Meeting I was impressed with a conviction that, for the future, the implement prize-sheet

of the Society should undergo an entire revision; and on my return to London I expressed these sentiments at the August Council Meeting; adding, that although no implement could be regarded as at present in a perfect state, still that the time might come when the implements might be arranged into classes for the purpose of more extended trials.

The trials at Carlisle, although made under unfavourable circumstances of weather, were viewed with great interest by numerous visitors, who appeared to give more than usual attention to their details. In addition to many large proprietors and distinguished agriculturists of the district, including the Earl of Burlington, &c., the meeting of the Society was also attended by Baron d'Usedom, the late envoy of the king of Prussia to this country, and the Baron Bettino Ricasoli, a distinguished landed proprietor of Tuscany, and one of the most intelligent patrons of agriculture in that part of the Continent.

I cannot conclude this Report without expressing my cordial thanks to my Colleagues and to the Judges, who were indefatigable in their exertions to effect the objects of the meeting, and to whom I was myself greatly indebted for their kindness and co-operation.

WM. FISHER HOBBS.

XXIV.—*Experiment on the Elementary Principles of Manure as applied to the Growth of Wheat.* By the late PH. PUSEY.

[It is believed that the following paper was written by its lamented author about the time at which he was prevented by severe domestic affliction from taking, at Lincoln, the honourable place assigned to him by the Society as its President for the second time, and shortly before his last illness. Its publication was delayed in the hope that he might live to give it his final correction; but, as it is, it will doubtless be received with interest by many of the members, as his last act in the service of the Royal Agricultural Society.]

HAVING a field of 8 acres set apart from common cultivation for the purpose of accurate experiment, year by year, on which five white crops having been grown in succession, the natural powers of the soil seemed sufficiently exhausted for the accurate test of artificial manures, it occurred to me that the most interesting use to be made of it might consist in the separate application of those elements which are supposed to constitute conjointly the efficacy of farmyard dung, and separately to act as fertilizers of the soil.

These, according to the received theory of agricultural science, will be comprised under four heads:—1. Nitrogenous substances;

2. Phosphorus; 3. Alkalis and principally potash; 4. That which constitutes the bulk of dung, the strawy matter, or, in chemical language, carbon.

The nitrogenous matter employed was nitrate of soda, which has been proved to be tantamount to ammonia for agricultural purposes; and I am obliged to employ this term nitrogenous matter because it is doubtful whether the ammonia be converted into nitric acid or the nitric acid into ammonia before they respectively enter the frame of the plant. Nitric acid, as I proved last year, acts directly upon vegetation, a result to which I felt justified in ascribing the novelty of a discovery; because, even if it had been demonstrated, which it had not, that this acid was the active principle in nitrate of soda, it would by no means follow as a matter of course that the acid would be found operative alone. In simple chemistry it would be so, but not in organic chemistry, as is well known to medical practitioners, who would by no means expect such indifference of reception by the animal stomach.

As the experiment relates to the fundamental principles of agricultural science, I may venture to describe it minutely. It was made by drilling separately superphosphate and peat-charcoal with wheat in the autumn, and top-dressing a portion of each lot in the spring with cubic saltpetre. The fourth element, potash, I thought better, from its solubility, to apply also in spring.

The question of the efficacy of superphosphate on wheat seemed to me especially interesting, because of its vigorous efficacy when applied singly to the growth of turnips.

The result of the trial is given in the following table:—

Per Acre.	Bushels of Wheat, per Acre.	Ditto with a topdressing of 170 lbs. Nitrate, per Acre.
4 cwt. of superphosphate	7	$19\frac{1}{3}$
6 cwt. of peat charcoal	$8\frac{3}{4}$	18
Nothing	$7\frac{1}{3}$	$19\frac{3}{10}$

It is evident that the superphosphate, though all-important for roots, has done nothing for the wheat, even on this poor and exhausted land. The charcoal would appear in the first column to have done something, but as that result is not confirmed by the combined trial, the difference must, I think, be accidental.

The fourth element, potash, was tried by top-dressing an acre of wheat with 1 cwt. of pearlash, which was so evidently inoperative on the crop as to render any separate thrashing unnecessary.

As far then as we can rely on this experiment, carefully made with soil duly prepared by previous exhaustion, the only element

of dung required by wheat is nitrogen, as contained in nitric acid or in ammonia. If this be true in an exhausted soil, where the plant can only find its other elements in the soil as it gradually crumbles down, or in the atmosphere, it must be still more true in practical farming, where they will be supplied ordinarily by manures applied to the other crops of each course.

I must admit, however, that as regards one element of farm-yard manure—the woody matter—the experiment is not conclusive, because, though carbon applied *as charcoal* did not operate upon wheat, the ligneous matter contained in dung is more easily decomposed, and might be operative; but as between the two leading articles of artificial manure, I mean the two Peruvian imports, guano and nitrate, it seems entirely conclusive, because it shows that the two ingredients which guano does, and nitrate does not contain, whether applied separately, or whether in combination with nitrogen, do not increase the yield of wheat; and this is worth remarking, because there exists still a latent suspicion that the pungent and compound animal excrement must contain more virtue than the inodorous mineral salt.

Their effects, no doubt, will vary relatively with variations of heat and moisture; but for *corn crops* nitrate appears a more certain top-dressing than guano. That it is sometimes more profitable is shown by the following experiment of Mr. Caird:—

In the centre of a 50-acre field, he says, 1 acre was left without manure, all the rest of the field receiving 2 cwts. of Peruvian guano per acre in autumn, at the time the seed was sown. The produce of the acre undressed has been tested against that of the adjoining acre, which received Peruvian guano, and this is the result:—

	£.	s.	d.
1 acre, with guano, 32 bushels, 63 lbs. weight per bushel, at 6*s.* 6*d.* per 60 lbs.	10	18	4
1 acre, without manure, 25½ bushels, 60 lbs. weight per bushel, at 6*s.* 6*d.* per 60 lbs.	8	5	9
	2	12	7
Cost of 2 cwt. of guano in 1853	1	0	0
Profit per acre, besides one-fourth more straw	1	12	7

The inferiority in the quality of the unmanured wheat, as shown by the weight per bushel, is worthy of notice, as well as the fact that the unmanured wheat was a week later in ripening than the other.

The second experiment was made to test the value of nitrate of soda and common salt as a top-dressing to wheat in spring, and the result in this case has been extremely profitable.* The wheat was sown in December, after a

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* It will be observed that, the nitrate having been used as a top-dressing in spring, and the guano at sowing time, the two experiments mentioned by Mr. Caird do not strictly admit comparison with each other; nor will Mr. Pusey be understood as drawing any general conclusion from them.

heavy crop of Swedes, all drawn off; and the whole field was top-dressed in April with 1 cwt. of nitrate of soda and 1 cwt. of salt per acre, given in two applications, at a fortnight's interval, 1 acre near the centre of the field having been left undressed. This and the adjoining acre have been thrashed, and yielded as follows:—

	£.	s.	d.
1 acre, with nitrate and salt, 42 bushels, worth 6*s*. 6*d*. ..	13	13	0
1 acre, without manure, 30 bushels, worth 6*s*. 6*d*.	9	15	0
	3	18	0
Cost of manure—1 cwt. nitrate, 18*s*.; 1 cwt. salt, 2*s*. ..	1	0	0
Profit per acre	2	18	0

In my own experiment the produce, it will be seen, is very low. Besides the gradual impoverishment of a naturally poor soil, the cutting winds of a harsh spring had almost blown the plants out of the soil, and had rendered the wheat in May almost invisible. But in a more sheltered part of the same field the result, as proved by a separate threshing, was greatly better.

	Nitrate.	Salt.	Yield in Wheat.
2½ acres . . .	3 cwt.	4 cwt.	65 bushels.

Being at the following rate,—

	Nitrate.	Salt.	Cost of Manure.	Yield.
1 acre . . .	135 lbs.	180 lbs.	23*s*.	26 bush.

For the sixth white crop in six years from the same field this result is certainly very respectable, being not far from the average produce of wheat land in England.

In conclusion, I am well aware that the only novelty in this experiment consists in its negative results, that is, in the inefficacy of certain chemical elements on the growth of the wheat plant. Still negative results are not altogether useless in mapping out for future investigators the unexplored fields of science, and may therefore, when carefully made, be placed on record for their service.

Even the positive result may serve also as one proof among many of the benefits of top-dressing. In some neighbourhoods this already ranks as an established practice. Thus in a Norfolk corn-dealer's circular, certainly a very practical testimony, I find it stated, "The yield of wheat has so gradually increased during the last few years, mainly through the use of artificial manures *used as top-dressings*, that it is difficult to define what is an average crop." Yet over the greater part of England probably no one would say that this *practice*, even if known, has become an ordinary act of husbandry. If it be permitted to advert to the cultivation of our French neighbours and friends, no one who has seen the farming of their northern departments will doubt that the practice would be preeminently useful there. They

have not the ready sale for meat, which leads many English farmers to buy artificial food rather than artificial manure; while if they had the sale, the scattered and minute shapes of their occupancies would impede them greatly in the rapid feeding of stock. The Imperial Government having lately shown its deep interest in the advancement of agriculture, by the deputation sent to our Lincoln meeting, I cannot but advert to this easy method of preventing deficient crops, from which France has lately suffered, as it struck me forcibly during a recent journey in that country, that one of the simplest improvements in agricultural practice would there prove the most effectual.

XXV.—*On the Value of Artificial Manures.* By J. Thomas Way, Consulting Chemist to the Society, 15, Welbeck Street, Cavendish Square.

It is now nearly seven years since I published in this Journal an extensive series of analyses of the different varieties of guano, with the view of fixing a standard of composition by which individual samples of this valuable manure might be judged. At the same time I endeavoured to show by reference to other available sources of its different ingredients at what price the purchaser of guano might be supposed to obtain these in the manure in question.

That these calculations have been of great service both to the consumer and manufacturer of manures I have every reason to believe, and the use which other chemists have subsequently made of the same method would seem to prove that it is not open to much objection. At a somewhat later period (1851) I extended the same calculations to superphosphate of lime.

Guano and superphosphate of lime do not however include all the ingredients entering into the composition of manures, and it has been thought desirable to fix the price of other substances on a similar principle, and at the same time to make such revisions in the list as the various changes or improvements in the manure trade might call for.

An admirable paper on this subject, lately published by Dr. Voelcker, of the Royal Agricultural College of Cirencester, will be found in the third volume of the Journal of the Bath and West of England Society. In the paper in question Dr. Voelcker explains very fully the difficulties lying in the way of a perfect valuation of the ingredients of manure, and his views on this subject so fully coincide with my own, that were his paper readily accessible to all the readers of this Journal I could be content to

refer them to it. As it is, however, I must very shortly state whence it comes that, with abundant knowledge of the composition of different manures, and of the prices at which their ingredients are to be purchased in the market, the chemist yet hesitates to fix with any degree of exactness the value of a compound manure from the analysis which he has made of it.

It will be found indeed that the greater part of the difficulty arises from the imperfect state of our knowledge with respect to vegetable nutrition, and consequently to the action of manures.

The obstacles to an exact valuation of manures appear to be as follows:—

1st. The agricultural value of different substances has not yet in all cases been clearly ascertained.

2nd. Where this value is ascertained the same substance is of different value in different soils, and especially under the influence of variation of climate.

3rd. The value is not the same for all crops.

4th. The mechanical condition of a manure materially affects its action.

5th. The commercial value of the same substance varies with the source; or, in other words, the same substance has a different value in the arts according to its origin or form of combination.

6th. The price of the same substance in the same form varies continually from a variety of causes.

I will shortly illustrate these different points.

1. "The agricultural value of different substances has not yet been clearly ascertained." Thus, of the very important element, nitrogen, we have three very different forms: in the salts of ammonia, where it is in combination with hydrogen; in the nitrates, where nitrogen is combined with oxygen; and in undecomposed animal matter, such as blood, flesh, &c., where it is united with carbon, oxygen, and hydrogen. We know that all these forms are very valuable, but we cannot yet be said to know the exact relative value of a given quantity of nitrogen in any one of them compared with another. So much is certain,—that they differ in immediate availability to vegetation; that salts of ammonia and nitrates produce a more rapid effect than dried blood or animal matter; and for this reason, if we require to use either of them for an immediate effect, as for instance to topdress wheat, we should choose the two former in preference. But we are not justified in saying that in the long run animal matters supplying a given amount of nitrogen may not be as valuable, or even more so, than an equivalent quantity of ammoniacal salts or nitrates.

Again, the relative value of manure, especially of liquid

manure (urine, &c.), when fermented or unfermented, has long been a subject of dispute with practical men. The superiority of effect in one case or the other is probably more due to incidental causes than to the actual condition of the nitrogen, but we have no means of proving that such is the case. The alkali potash is a necessary element of vegetation, but it is contained in considerable quantity in most soils, and in the ordinary course of agricultural operations is more or less restored in the farm manure. There is no very satisfactory evidence of its value as a direct application to the soil, or, at all events, of the exact amount of that value. Instances of this kind might easily be multiplied, but it is obvious that our power to value manures is greatly crippled by the insufficiency of our present knowledge of their effects.

2. "Where the general value is ascertained, the same substance is of different value in different soils, and especially under the influence of variation of climates." In proof of this assertion it is sufficient to point to the well-known fact that bones, which require the influence of the air to bring them into operation, have altogether failed in heavy soils, where a ready-formed source of ammonia, such as guano, has produced the best effect.

Again, certain soils contain a superabundance of particular ingredients of manure; the use of it then becomes unnecessary, and its cost in a manure is not compensated by any advantage from its application. Some of the surface soils of the greensand, as at Farnham, contain large quantities of phosphate of lime, and it results from the experience of Mr. Paine, whose land is so situated, that the direct application of phosphate of lime to such land is useless. In buying a manure, therefore, he could not afford to pay for this ingredient. Difference of climate is perhaps even more than variety of soil productive of modification in the action of manures. In the North guano is extensively used for turnips; in the South of England its employment for this crop is comparatively limited.

3. "The value is not the same for all crops." It seems to be proved beyond all doubt by the experiments of Mr. Lawes and Dr. Gilbert that ammonia is the manure for direct application to the cereals; phosphate of lime being properly applied to turnips and other root-crops, but being quite without effect upon wheat.*

Now, although a certain quantity of ammonia in a turnip-manure may not only be allowable but desirable, and possibly, on the other hand, a small portion of phosphate of lime may improve a corn-

* The more recent experiments of these gentlemen on barley and oats induce them to believe that soluble phosphate of lime has in some cases a beneficial action on these crops.

manure, yet their distinctive character for one and the other crop remains and influences the nature of a compound manure accordingly. It is true that manure, when once placed in the soil, may be supposed to remain there for a future crop, but we cannot say that it will then be in the same available condition for plants; and the true policy would undoubtedly be to add to any crop only that manure which it can at once appropriate. Perhaps of all other sources of difficulty in the estimation of the value of a manure this is the greatest—inasmuch as from the very nature of the substances employed in making manure a more or less mixed product is most commonly obtained.

4. "The mechanical condition of a manure materially affects its value." The state of dryness, the size of the particles, the more or less perfect mixture of the various materials, all have an influence on the action of a manure which is not and cannot be taken account of in the statement of its composition; so that a superior value in regard to the proportion of the ingredients may be more than neutralized by their faulty pulverization or admixture, leading to inequality of distribution and irregularity of the crop produced.

5. "The commercial value of the same substance varies with the source," &c. Ammonia, in sulphate of ammonia, costs at the present price of that salt (15*l.*) about $7\frac{1}{4}$*d.* per lb., whilst in Peruvian guano, at its present high price of 11*l.*,* the ammonia costs about $4\frac{3}{4}$*d.* per lb. In valuing a manure, which of these two data are we to employ? The reason for the higher price of ammonia in sulphate is evidently that this salt has uses other than agricultural, which regulate its price, whilst guano has only one issue for consumption.†

6. "The price of the same substance in the same form varies continually from a variety of causes." It is obvious that as the supply of manure barely keeps pace with the requirements of agriculture, a variation of the prices of the ingredients of manure may be expected to occur at particular seasons. Accordingly, in the autumn of the year sulphate of ammonia and other such substances, chiefly used as top-dressings in the spring, will be cheaper than at other periods. Nitrate of soda, which is now largely used as a manure, fluctuates in price not only with the manure-market, but with a rise or fall in value of nitrate of potash.‡ Sulphate of potash to a great extent takes its price from that of alum, of which it is an ingredient.

* The price of guano, as above quoted, was given to me as that of the importers, on the 1st of the present month of November.

† Very recently guano has come to be used in dyeing, some very beautiful specimens of silk, of which the colour was due to the employment of this substance, being shown in the late French Exhibition.

‡ Nitrate of potash, which, as is well known, is chiefly used in the manufacture

It is evident then that even supposing that we should be successful in fixing a fair price for each different ingredient of manure, such a standard can have no permanency, but must be modified from time to time according to variations in value of each substance.

Having, then, explained the difficulties which present themselves in any attempt to attach a money-value to the ingredients of manure, I shall now endeavour to furnish such data as will enable the purchaser of manure to calculate with tolerable correctness the price of any manure which may come under his notice; but I repeat that in so doing he should use the utmost caution.

I give in a Table the present price of a variety of different substances which are either used directly in the manufacture of manure, or are necessary for our calculation. They have been obligingly furnished to me by individuals whose information on the subject is unquestionable.

TABLE I.

		£.	s.
Sulphate of Ammonia		15	0
Muriate of Ammonia, 95 per cent.		26	0
Nitrate of Potash (crude), 85 to 90 per cent.	32*l.* to	40	0
Sulphate of Potash		15	0
Carbonate of Potash, 97 to 98 per cent.		76	0
American Potash, 75 per cent.		35	0
Nitrate of Soda,* 95 per cent.	18*l.* 10*s.* to	19	0
Sulphate of Soda, 95 per cent.		5	10
Common Salt (clean)		1	6
Agricultural Salt		1	0
Sulphate of Magnesia (rough), 90 per cent.		5	0
,, (pure), 97 per cent.		8	10
Sulphate of Lime (mineral gypsum)		1	10
,, (precipitated)		1	0
Coprolite (ground), 52 per cent. of Phosphate of Lime		3	15
Bone Ash, 70 per cent. of Phosphate of Lime	5*l.* 17*s.* 6*d.* to	6	0
Animal Charcoal, 70 per cent. of Phosphate of Lime	5*l.* 15*s.* to	6	0
Bones (half-inch boiled)	6*l.* 6*s.* to	6	10
Guano (Peruvian)	11*l.* to	11	10

From these figures we are of course able to calculate the cost of any substance (potash, phosphate of lime, ammonia, &c.) as supplied from one or another source. This calculation is perfectly easy when in a compound only one ingredient is of agricultural importance, as for instance in muriate of ammonia, which is only valuable for its ammonia; but it is attended with very much more difficulty when (as in nitrate of potash or bones) there are two or more ingredients of agricultural value. In this case we can only adopt the method employed by me in my early valuations of guano and superphosphate, of ascertaining the cost

of gunpowder, is now very dear. Nitrate of soda, although unfit for the use of the maker of gunpowder, on account of its tendency to absorb moisture from the air, is capable of conversion into that salt. Hence the relation of price which they hold in the market.

* Usually 14*l.* to 17*l.*

of each ingredient, by reference to the other sources of supply and sharing the advantage or loss of the comparison in proper proportion between the different ingredients. An example will best serve to make this plain.

Let us suppose that a farmer wishes to apply to his soil nitric acid in the state of a nitrate, and potash in some form of that alkali; it is obvious that he could most readily do this by means of nitrate of potash, but the question arises as to the economy of such a proceeding.

Nitrate of potash containing 90 per cent. of real nitre, we shall suppose to cost 40*l.* per ton, which corrected for pure nitrate would be 44*l.* 8*s.* Nitrate of soda containing 95 per cent. real nitrate is to be taken at 18*l.* 10*s.* per ton, which corrected, as in the other case, will be 19*l.* Now 1 ton of nitrate of soda contains 1423 lbs. nitric acid, and as we shall assume that the soda is of no agricultural value, those 1423 lbs. of nitric acid will have to bear all the cost of the salt. At this rate we shall buy nitric acid in nitrate of soda at $3\frac{2}{10}$*d.* per lb. 1 ton of nitrate of potash contains 1197 lbs. nitric acid and 1043 lbs. of potash: these 1197 lbs. nitric acid could be supplied in the state of nitrate of soda for 15*l.* 19*s.*, and consequently the diffference between this sum and 44*l.* 8*s.* (the cost of a ton of nitrate of potash) or 28*l.* 9*s.*, would be the cost of the potash alone, or at the rate of $6\frac{1}{2}$*d.* per lb. Now in sulphate of potash, as will be seen by a Table presently to be given, potash is bought at about $3\frac{1}{4}$*d.* per lb., or just half the above price.

It is obvious, therefore, that in buying nitric acid and potash in the form of nitrate of potash we should buy one or both of them much too dearly. Indeed, in buying the ingredients of 1 ton of nitrate of potash separately, in the form of sulphate of potash and nitrate of soda we shall have a cost as follows:—

	£.	s.
1197 lbs. of Nitric Acid at $3\frac{2}{10}$*d.* per lb.	15	19
1043 lbs. of Potash at $3\frac{3}{10}$*d.* per lb.	14	6
Making the total cost of the two ingredients	30	5

Instead of 44*l.* 8*s.*, which it would be if bought as nitrate of potash.

The proper way in this case is to share the additional cost of the last salt *pro ratâ* between the two ingredients. In this way we find that nitrate of potash furnishes nitric acid at $4\frac{8}{10}$*d.*, and potash at $4\frac{9}{10}$*d.* per lb.

In drawing up a Table to be used in the calculation of the value of manures, I propose to give the results in three different ways, in order that each person may employ that method which appears to him the simplest.

The following Table gives the cost of all the different substances, as calculated by myself:—

TABLE II. For calculating Money Value of Manures.

	Per lb.		Per Cent. per Ton.*		Per Ton.		
	s.	*d.*	*s.*	*d.*	£.	*s.*	*d.*
Ammonia in Sulphate	0	$7\frac{3}{10}$	13	7	68	3	0
,, in Muriate	0	$9\frac{6}{10}$	17	11	89	12	0
,, as supplied by Bones	0	$4\frac{8}{10}$	8	$11\frac{1}{2}$	45	9	0
,, ,, Dried Blood ..	0	$5\frac{9}{10}$	11	0	55	0	0
,, ,, Peruvian Guano ..	0	$4\frac{7}{10}$	8	9	44	2	0
,, ,, Nitrate of Potash	1	$3\frac{1}{2}$	28	0	140	0	0
,, ,, Nitrate of Soda ..	0	$10\frac{4}{10}$	17	9	89	1	0
Biphosphate of Lime	0	5	9	$7\frac{1}{2}$	48	3	6
Soluble neutral Phosphate of Lime	0	$3\frac{1}{2}$	6	$6\frac{1}{2}$	32	13	4
Phosphate of Lime in Coprolite	0	$0\frac{2}{3}$	1	3	6	5	0
,, in Bone Ash	0	$0\frac{91}{100}$	1	$8\frac{1}{2}$	8	11	5
,, in Animal Charcoal ..	0	$0\frac{88}{100}$	1	$7\frac{3}{4}$	8	2	2
,, in Bones	0	$0\frac{6}{10}$	1	2	5	14	4
,, in Peruvian Guano ..	0	$0\frac{59}{100}$	1	1	5	11	0
Potash in Sulphate	0	$3\frac{3}{10}$	6	2	30	16	0
,, in Nitrate	0	$4\frac{9}{10}$	9	2	45	14	0
,, in American Potashes	0	$7\frac{8}{10}$	14	6	72	16	0
Magnesia in Sulphate	0	$3\frac{4}{10}$	6	4	31	14	0
Soda in Sulphate	0	$1\frac{4}{10}$	2	9	13	14	9
,, supplied by Common Salt	0	$0\frac{22}{100}$	0	$4\frac{1}{2}$	1	17	9
Organic Matter, nitrogenous	0	$0\frac{1}{10}$	0	$2\frac{4}{10}$	1	0	0
,, non-nitrogenous	0	$0\frac{1}{20}$	0	$1\frac{2}{10}$	0	10	0
Alkaline Salts	0	$0\frac{1}{10}$	0	$2\frac{4}{10}$	1	0	0
Sulphate of Lime	0	$0\frac{1}{10}$	0	$2\frac{4}{10}$	1	0	0
,, of Soda (dry)	0	$0\frac{61}{100}$	1	$1\frac{1}{2}$	5	15	0
,, of Potash	0	$1\frac{8}{10}$	3	4	16	13	0
,, of Magnesia (dry)	0	$1\frac{22}{100}$	2	3	11	7	0
Sulphuric Acid (real) in Sulphate of Lime ..	0	$0\frac{30}{100}$	0	$5\frac{1}{4}$	2	11	6
Adopted Averages.							
Nitrogen	0	$7\frac{3}{10}$	13	6	68	0	0
Ammonia	0	6	11	2	56	0	0
Phosphate of Lime	0	$0\frac{3}{4}$	1	5	7	0	0
Soluble Phosphate of Lime	0	$3\frac{1}{2}$	6	$6\frac{1}{2}$	32	13	4
Potash	0	$3\frac{3}{10}$	6	2	30	16	0

It will be seen that ammonia, or its equivalent in nitrogen, varies in price from $4\frac{7}{10}$*d.* per lb. in Peruvian guano, to nearly $10\frac{1}{2}$*d.* in nitrate of soda.

I do not include nitrate of potash, which has always too high a price for manure, and is at this moment excessively dear.

* The column headed "Per Cent. per Ton" is perhaps somewhat difficult of comprehension. It is, however, a method of valuation familiar enough to manufacturers and others engaged in the purchase and sale of commercial articles. Thus, to give an illustration, soda ash (impure carbonate of soda) is sold at about $2\frac{1}{4}$*d. per cent. per cwt.*, that is to say, a hundredweight of it is worth $2\frac{1}{4}$*d.* for every per cent. of *real* soda in it. If then the soda ash contains 50 per cent. real soda, one hundredweight of it will be worth fifty times $2\frac{1}{4}$*d.*, or 8*s.* $4\frac{1}{2}$*d.* In the table the price per cent. refers to *a ton*; so if a manure contains 20 per cent. of soluble phosphate, one ton of the manure will be worth, for that ingredient, 6*s.* $6\frac{1}{2}$*d.* multiplied by 20, or 6*l.* 10*s.* 10*d.* The application of this method is seen in the text at page 542.

Phosphate of lime again costs from a little more than a half-penny to nearly a penny per lb., according to its origin.

Now, to enable us to come to any estimation of the value of a manure, we must adopt some distinct standard, and it will be seen that I have taken as the price of ammonia 6*d*. per lb. When guano is bought, the purchaser will obtain it at a cheaper rate; when sulphate of ammonia is the source, at a higher cost. If there existed any unlimited supply of ammonia not in mixture with other substances, then undoubtedly the price would be regulated by that supply.

Guano contains, as we know, other substances besides ammonia, and in fixing the price of the latter all the other ingredients are taken into account. We cannot therefore buy ammonia in guano without buying phosphate of lime, potash, &c. This circumstance, together with the fact that although the importations of guano are enormous the supply is not always equal to the demand, prevents us from fixing the cost of ammonia upon the basis of guano.

At the end of this paper I propose to give a great number of analyses of guano and superphosphate of lime executed in this laboratory since the commencement of the year 1852, and subsequently therefore to my paper on these manures. It will then be seen on what grounds I have given for ammonia and soluble phosphate of lime, the prices set against them in the Table. After all, these two elements of manure are those of the greatest importance, and their just valuation is of paramount necessity.

At the end of the Table I have placed the numbers which I adopt as averages for the principal ingredients of manure, namely, ammonia, phosphate of lime (soluble and insoluble), and potash. I have also given the prices to be apportioned to several salts, such as sulphate of soda, &c., as these salts are sometimes stated in the result of an analysis. There is a seeming discrepancy in the price of these and that mentioned in the previous Table, but it will be remembered that the latter refers to the commercial or impure article, whilst the prices in this table are those of the absolute substance.

In calculating the value of ammonia, potash, &c., as supplied by their sulphates, I have altogether omitted the cost of the sulphuric acid, as this substance in the form of sulphate of lime is so abundantly met with in soils themselves; and its cost, if actually supplied in that form, is so slight as not materially to affect that of the other ingredient. Thus a ton of sulphate of ammonia contains 1194 lbs. of sulphuric acid, which would be supplied in a little more than a ton of sulphate of lime, costing about 20*s*., or one-fifteenth of the whole price of the sulphate of

ammonia. The value of ammonia and phosphate of lime in bones is calculated on the supposition that these latter cost 6*l.* 10*s.* per ton—that they contain 50 per cent. of phosphate of lime, and 7·3 per cent. of nitrogen.

Dried blood is considered to contain 12 per cent. of nitrogen, and to cost from 8*l.* to 9*l.* per ton.

In the Table it will be observed that organic matter, free from nitrogen, is valued at 10*s.* per ton; when containing nitrogen in large quantity, at 20*s.* per ton. For instance, dried blood contains 80 or 88 per cent. of organic matter, chiefly or entirely nitrogenous. In calculating the value of dried blood I should add to the price of the ammonia $2\frac{1}{2}d.$ ($2\frac{4}{10}d.$) for every one per cent. of organic matter; of course where little nitrogen or ammonia exists in a manure, the organic matter will be estimated at the lower price.

In analyses of manures it is very usual, after recapitulation of the various ingredients, to give as "alkaline salts and loss," the difference between the numbers obtained and 100 parts. These alkaline salts will usually be principally soda, or would otherwise by a careful analist be mentioned as salts of potash; I therefore attach to them only a very small value, namely, 1*l.* per ton. Let us now see in what way the Table above is to be made use of in calculating the value of a manure. We must of course suppose that the analysis of the manure is before us: and for the sake of illustration, we may take what may be considered a good specimen of superphosphate of lime. Calculating by the first column we shall proceed as follows:—

A ton contains 2240 lbs. By multiplying the percentage of any ingredient by 2240, and dividing it by 100, or what is the same thing, by multiplying by 22·4, we at once obtain the number of pounds of the substance in a ton of the manure; this multiplied by the price per lb., as taken from the table, will give the total value of this ingredient per ton of the manure.

	Per Cent.			£.	s.	d.
Moisture	12·00					
Organic Matter, &c.	17·00	= 381	lbs., which, at $\frac{1}{20}d.$, are worth	0	1	7
Sand	4·00					
Soluble Phosphate	$16\frac{1}{2}$	= $369\frac{1}{2}$	lbs., which, at $3\frac{3}{4}d.$, are worth	5	7	9
Insoluble Phosphate	13	= 291	lbs., which, at $\frac{3}{4}d.$, are worth	0	18	2
Sulphate of Lime ..	41	= 915	lbs., which, at $\frac{1}{10}d.$, are worth	0	7	7
Alkaline Salts ..	2	= 44·8	lbs., which, at $\frac{1}{10}d.$, are worth	0	4	5
Ammonia	1·0	= 22·4	lbs., which, at 6*d.*, are worth	0	11	2
	Giving			7	10	8

as the total value of the ingredients of a ton of good superphosphate.

This method, however, is laborious, and indeed the second column of the table obviates the necessity of one-half of the cal-

culations; thus by multiplying the percentage of an ingredient of the analysis by the value by one per cent. of it as given in the Table, we at once arrive at the result. Thus—

				£.	s.	d.
Organic Matter ..	17·0	per cent.,	at $1\frac{2}{10}d.$	0	1	8
Soluble Phosphate	16·5	,,	at 6s. $6\frac{1}{2}d.$	5	7	11
Insoluble Phosphate	13·0	,,	at 1s. 5d.	0	18	5
Sulphate of Lime	41·0	,,	at $2\frac{4}{10}d.$	0	8	2
Alkaline Salts ..	2·0	,,	at $2\frac{5}{10}d.$	0	0	5
Ammonia	1·0	,,	at 11s. 2d.	0	11	2
			Giving	7	7	9

as the price per ton; the few pence difference in the calculations being due to the neglect of small fractions in the calculations of value per lb. in the previous instance.

But by far the easiest method of arriving at the desired result, is by the use of the third column. This plan (which in justice I should state I first saw employed by Mr. Nesbit, who, to my knowledge, has used it for several years) consists in treating the percentage of an analysis as so many parts of 100 tons of the manure—20 per cent. means of course 20 parts in 100—whether grains, lbs., or tons are in question. Now if we take one by one the substances mentioned in an analysis, and multiply the percentage quantities there given by the price of a ton of the particular ingredient, as ascertained by the Table, we shall obtain the aggregate cost of 100 tons. Nothing is then easier than to divide this amount by 100 in order to obtain the price of one ton. In fact this is accomplished by merely striking off two figures from the sum.

I should here mention that although I have thought it necessary to give the exact sum in pounds, shillings, and pence, resulting from my calculations, it is quite unnecessary to go so minutely to work. To save calculation, therefore, the reader will see that he may in many cases dispense with the shillings and pence which figure in the cost placed against a ton of this or that ingredient of manure, and that he may adopt the nearest whole number for his standard. Taking for our basis the analysis of superphosphate before given, I proceed to ascertain its value by the use of the third column of the Table.

				In 100 Tons.	
				£.	s.
Organic Matter ..	(17	per cent.)	17 tons at 1*l*.	17	0
Soluble Phosphate	($16\frac{1}{2}$	,,	) $16\frac{1}{2}$ tons at 32*l*. 13*s*. 4*d*., say 33*l*.	544	10
Insoluble Phosphate	(13	,,	) 13 tons at 7*l*.	91	0
Sulphate of Lime	(41	,,	) 41 tons at 1*l*.	41	0
Alkaline Salts ..	(2	,,	) 2 tons at 1*l*.	2	0
Ammonia	(1	,,	) 1 ton at 56*l*.	56	0
				751	10

We have here 751*l.* 10*s.* as the cost of 100 tons of the manure; by striking off the two last figures in the division of pounds sterling (thus 7,51*l.*), we have $7\frac{5}{10}$*l.*, or 7*l.* 10*s.* as the value of the manure.

I can confidently recommend this method of "appraising" manures, as affording a rapid and easy result. As it deals with large quantities which are subsequently reduced to one-hundredth of the amount, minute calculations may be avoided, and the result will still exhibit only a slight discrepancy which is practically unimportant. Thus in the last instance soluble phosphate was taken at 33*l.* per ton instead of 32*l.* 13*s.* 4*d.*; the difference, 6*s.* 8*d.*, multiplied by $16\frac{1}{2}$ times, would amount to 5*l.* 0*s.* 6*d.* on 100 tons of the manure, or about 1*s.* per ton, which of course is quite within the limits of error.

A class of manures has lately been introduced under the names of "Nitrophosphates," or "Ammoniacal superphosphates," by which names it is intended to indicate a mixed manure, containing a larger proportion of nitrogen (or ammonia), and generally a smaller percentage of soluble phosphate than is to be met with in ordinary superphosphates. For the sake of illustration we may calculate the value of such a substance by reference to the Table.

Thus, taking sample 51 in the list of superphosphates at page 549, we obtain the following results in 100 tons:—

				For 100 Tons.	
				£.	s.
Moisture	8·90	per cent.			
Organic Matter, &c.	19·72	,,	at 1*l.* per ton	19	15
Insoluble Matter	..				..
Soluble Phosphate	9·63	,,	at 33*l.* ,, ...	319	0
Insoluble Phosphate	13·37	,,	at 7*l.* ,, ...	93	10
Sulphate of Lime ..	39·77	,,	at 1*l.* ,, ...	40	0
Alkaline Salts ..	4·8	,,	at 1*l.* ,, ...	4	16
Ammonia	3·88	,,	at 56*l.* ,, ...	218	0
				695	1

or, as nearly as may be, 7*l.* per ton.

Here we find that a larger percentage of ammonia and a smaller proportion of soluble phosphate are made to balance each other, so that the value of the manure remains about the same.

On the other hand, if we select from the list of superphosphates what would by the maker be emphatically called a "Nitro" or "Ammonia" phosphate, we shall find a higher value for it; thus No. 56 in the list would give us the following results for 100 tons:—

			For 100 Tons. £. s.
Moisture	8·40 per cent.		
Organic Matter, &c.	25·75 ,,	at 1*l.* per ton	25 15
Insoluble Matter ..	6·63 ,,		..
Soluble Phosphate	18·20 ,,	at 33*l.* ,, ...	600 0
Insoluble Phosphate	6·91 ,,	at 7*l.* ,, ...	48 0
Sulphate of Lime ..	38·78 ,,	at 1*l.* ,, ...	38 15
Alkaline Salts ..	1·19 ,,	at 1*l.* ,, ...	1 4
Ammonia	4·29 ,,	at 56*l.* ,, ...	240 16
			954 10

or 9*l.* 10*s.* per ton.

This manure would probably be sold at from 8*l.* 10*s.* to 9*l.* per ton, and it would be worth this price, providing that the principle of combining a considerable percentage of nitrogen with soluble phosphate be fully affirmed. As I said before, such an assumption is absolutely necessary in these calculations; indeed without its acceptance the manufacturer is egregiously in error in producing manures of this class. I shall content myself with one more illustration of the use of this method of calculation. The sample 25 on the list of superphosphates has evidently been made with a fair quantity of phosphate of lime, but from want of knowledge of the methods of manufacturing the manure, probably rather than any desire to supply an inferior article, the quantity of sulphuric acid has been too small to dissolve a proper quantity of phosphate. Mark the result in the value of the article:—

			For 100 Tons. £. s.
Moisture	13·10 per cent.		
Organic Matter, &c.	8·75 ,,	at 1*l.* per ton	8 15
Insoluble Matter ..	8·15 ,,		..
Soluble Phosphate	8·10 ,,	at 33*l.* ,, ...	271 6
Insoluble Phosphate	26·76 ,,	at 7*l.* ,, ...	187 10
Sulphate of Lime ..	33·00 ,,	at 1*l.* ,, ...	33 0
Alkaline Salts ..	4·75 ,,	at 1*l.* ,, ...	4 15
Ammonia	1·30 ,,	at 56*l.* ,, ...	72 8
			577 14

or 5*l.* 15*s.* per ton.

This instance, however, brings to view a weakness in the method of calculation, and may very safely be referred to as showing how much judgment is required in the application of any money test to manures. The sample of superphosphate, of which the analysis is here given, is certainly not worth 5*l.* 15*s.* per ton, for it is very deficient in soluble phosphate; but the great proportion of insoluble phosphates tends to enhance the apparent value, amounting as it does to nearly 2*l.* per ton of the sum. The fact is, that insoluble phosphate in a manure, unless it proceeds from bones or guano, is not worth, agriculturally, the

price that it costs, or that we give it credit for; and the manufacture of superphosphate of lime will be imperfect so long as insoluble phosphate figures as one of its ingredients.

To justify the prices which I have adopted for different elements of manure, I shall now give analyses of guano and superphosphate of lime from my laboratory books. I begin with guano, of which, since the publication of my paper on that manure, a very great number of samples have reached me from all quarters.

It will be remembered that the average quantity of phosphate of lime in Peruvian guano was formerly fixed by me at 24 per cent.; and this number has been usually adopted by other chemists, either from their own analyses, or on my authority.

Since the publication of my paper on guano, it became evident that the methods of analysis were not so accurate as they might be. The reader is referred to a note at the end of this paper for a detailed explanation on this subject; and it will be sufficient to state, that upon more refined examination, the average proportion of phosphate of lime was found to be more nearly 30 per cent., of which nearly 7 per cent. occurs in the state of soluble phosphate. This circumstance has a very material influence on the value of guano, and on the price of its constituents, and will, of course, affect the relation of this manure to other manures in the market. Since the commencement of the year 1852, the more accurate method of analysis has always been employed in this laboratory; and I gladly take this opportunity of publishing a body of results serving still more definitely to fix the value of this very important manure. The following Table gives the analyses of a great number of samples of Peruvian guano, received for analysis from all quarters, but mainly from members of this Society, during the last four years.

TABLE III.—Analyses of Genuine Samples of Peruvian Guano, 1852 to 1855 inclusive.

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia	Sand.	Phosphates of Lime and Magnesia.	Alkaline Salts.	Nitrogen.	Equal to Ammonia	Phosphoric Acid in Alkaline Salts.	Equal to Soluble Phosphate of Lime.
1	18·36	47·27	1·43	23·57	9·37	13·73	16·67	3·72	7·67
2	13·83	51·64	1·44	23·48	9·61	13·18	16·00	3·70	7·62
3	13·44	52·66	1·58	21·30	11·02	14·46	17·55	3·34	6·88
4	15·23	49·73	2·63	21·63	10·78	13·04	15·83	3·74	7·71
5	14·64	51·37	2·16	23·41	8·42	14·43	17·52	3·35	6·90
6	14·22	49·83	3·32	19·30	13·33	13·43	16·30	2·84	5·85
7	14·27	52·12	1·34	22·41	9·86	14·03	17·04	3·14	6·47
8	13·05	52·57	1·70	22·62	10·06	14·24	17·29	4·87	10·04
9	15·25	51·84	2·74	21·04	9·13	13·78	16·73	3·87	7·97
10	14·71	48·93	2·19	21·59	12·58	12·73	15·45	3·19	6·57
11	12·48	51·93	1·99	22·38	11·22	13·55	16·45	3·27	6·74

Analyses of Genuine Samples of Peruvian Guano, &c.—*continued.*

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia	Sand.	Phosphates of Lime and Magnesia.	Alkaline Salts.	Nitrogen.	Equal to Ammonia	Phosphoric Acid in Alkaline Salts.	Equal to Soluble Phosphate of Lime.
12	14·72	49·87	1·25	23·51	10·65	13·78	16·63	2·64	5·44
13	16·89	49·11	1·59	22·75	9·66	11·67	14·17	2·60	5·36
14	11·40	54·14	1·60	21·08	11·78	13·37	16·23	3·89	8·06
15	6·60	56·43	1·64	24·56	10·77	13·95	16·93	2·17	4·47
16	12·57	51·07	1·18	22·88	12·30	13·98	16·97	3·20	6·60
17	12·30	52·34	1·60	23·42	10·34	14·32	17·39	2·45	5·05
18	10·22	57·49	1·40	23·21	7·68	15·40	18·70	1·30	2·68
19	12·80	50·38	3·02	23·26	10·54	13·36	16·22	3·21	6·60
20	15·73	50·21	2·05	21·13	10·88	13·14	15·96	3·03	6·24
21	11·20	50·80	4·24	24·69	9.07	14·00	17·00	2·74	5·65
22	9·14	56·15	1·58	25·00	8·13	14·91	18·10	3·04	6·26
23	19·04	47·46	0·90	24·90	7·70	12·35	14·99	2·26	4·66
24	21·42	45·17	3·14	22·58	7·69	12·16	14·76	3·05	7·69
25	13·38	50·40	2·05	28·65	5·52	14·35	17·42	2·05	5·52
26	13·57	46·85	5·60	23·30	10·68	14·43	17·52	3·37	6·94
27	17·15	48·10	1·18	26·35	7·22	13·28	16·11	2·72	5·61
28	16·75	50·66	2·29	18·50	11·80	13·68	16·61	3·53	7·61
29	22·26	46·99	1·28	21·52	7·95	12·69	15·41	2·76	5·69
30	12·51	47·05	4·91	27·54	7·99	12·50	15·18	4·21	8·67
31	15·37	49·69	1·25	22·38	11·31	14·34	17·41	3·70	7·62
32	14·70	52·09	1·19	21·72	10·30	14·61	17·74	4·69	9·67
33	10·47	57·48	1·08	21·24	9·73	13·70	16·64	2·82	5·81
34	12·02	51·82	2·45	27·69	6·02	13·93	16·91	2·68	5·52
35	15·18	51·36	1·26	22·58	9·62	14·97	18·17	2·97	6·12
36	8·29	57·31	1·12	21·93	11·35	14·17	17·20	5·43	11·19
37	10·80	56·16	1·39	22·26	9·39	15·45	18·76	2·95	6·08
38	8·01	56·98	1·71	24·09	9·21	14·29	17·35	2·68	5·52
39	16·98	49·42	1·08	21·60	10·92	12·96	15·74	4·86	10·02
40	15·49	49·44	2·69	24·60	7·78	14·31	17·37	2·87	5·92
41	11·53	51·47	1·19	19·59	16·22	13·92	16·90	4·16	8·58
42	17·50	49·22	1·51	22·84	8·93	13·66	16·58	2·95	6·04
43	16·70	50·84	1·74	22·30	8·42	13·29	16·14	3·46	7·13
44	16·11	50·24	1·87	26·45	5·33	12·05	14·63	1·04	2·14
45	8·29	59·39	1·27	24·90	6·15	13·94	16·92	2·60	5·36
46	6·66	59·80	1·17	23·69	8·68	15·22	18·48	3·36	6·92
47	9·02	56·55	0·78	24·92	8·73	12·98	15·76	3·68	7·58
48	13·19	54·06	1·37	23·83	7·55	14·12	17·27	2·58	5·32
49	12·09	54·07	1·41	25·10	7·33	13·81	16·75	2·86	5·89
50	14·65	54·13	0·90	26·92	3·40	15·50	18·82	0·99	2·03
51	9·67	55·11	1·17	22·18	11·87	14·61	17·74	3·84	7·91
52	8·03	56·70	1·23	24·22	9·82	14·57	17·67	3·07	6·35
53	17·17	50·56	1·34	18·88	12·10	13·39	16·25	4·03	8·05
54	15·18	50·96	..	22·57	11·29	13·40	16·27	2·71	5·58
55	15·58	48·00	1·01	18·57	16·84	11·54	14·01	6·21	12·80
56	18·15	47·35	1·47	24·94	8·09	11·72	14·23	1·61	3·32
57	13·36	55·04	1·51	23·45	6·64	16·07	19·51	3·11	6·41
58	14·45	53·24	1·46	20·35	10·50	14·20	17·24	4·07	8·39
59	17·15	50·66	0·53	22·31	9·35	13·20	16·03	3·86	7·95
60	17·72	47·14	2·32	20·31	12·51	12·72	15·44	3·60	7·42
61	10·31	54·96	1·25	26·11	7·37	14·27	17·32	3·46	7·13
62	16·82	53·40	1·85	23·31	4·62	14·16	17·19	2·10	4·32
63	15·23	48·92	1·91	21·93	12·01	11·44	13·88	4·17	8·59
64	10·81	55·88	1·51	24·56	7·24	14·39	17·47	3·01	6·20

Analyses of Genuine Samples of Peruvian Guano, &c.—*continued.*

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia	Sand.	Phosphates of Lime and Magnesia.	Alkaline Salts.	Nitrogen.	Equal to Ammonia	Phosphoric Acid in Alkaline Salts.	Equal to Soluble Phosphate of Lime.
65	8·38	55·52	9·78	11·07	15·25	17·08	20·75	4·71	9·70
66	15·03	50·68	1·94	22·02	10·33	13·22	16·06	4·66	9·60
67	12·14	52·61	1·49	24·58	9·18	13·47	16·35	2·71	5·58
68	16·92	50·30	1·78	22·05	8·95	12·02	14·60	3·81	7·65
69	8·23	55·62	1·20	25·30	9·65	14·21	17·25	3·19	6·57
70	11·61	53·47	1·71	20·73	12·48	12·69	15·40	5·08	10·47
71	12·89	54·12	1·14	20·27	11·58	13·92	16·90	5·61	11·56
72	7·91	59·03	1·49	18·77	12·80	11·28	13·69	5·70	11·85
73	14·85	48·80	2·66	24·63	9·06	11·17	13·56	2·49	5·13
74	14·48	51·03	1·46	25·25	7·78	11·57	14·05	2·57	5·30
75	15·06	50·62	1·87	23·73	8·72	11·46	13·91	3·51	7·23
76	18·67	49·35	1·21	20·62	10·15	13·16	15·96	2·61	5·38
77	16·75	51·26	1·27	22·52	8·20	13·96	16·95	2·26	4·70
78	11·37	54·52	0·82	18·52	14·77	13·49	16·38	5·08	10·47

These seventy-eight analyses give us the mean composition of Peruvian guano, as under—

Moisture	13·67
Organic Matter and Salts of Ammonia *	52·05
Sand, &c.	1·83
Phosphates of Lime and Magnesia	22·78
Alkaline Salts, containing 3·34 Phosphoric Acid equal to 6·89 Soluble Phosphate of Lime	9·67
	100·00

* Containing Nitrogen 13·61, equal to Ammonia 16·52.

Comparing these numbers with the results formerly published, we find that the chief difference is in the phosphate of lime. The percentage of ammonia indeed, as found in the samples of the last four years, is somewhat lower than I formerly found it, being, on the average of the earlier experiments, 17·4, whereas it is in the present case 16·5 per cent.; but it must be remembered that the former series was obtained direct from the cargoes, whilst the greater number of the analyses now recorded were made from samples in the market, and therefore more correctly represent the general average composition of the manure; the chief difference, however, as above stated, is in the proportion of phosphates, and in the determination of the soluble phosphates. Now it must be borne in mind that phosphoric acid, whether it be soluble from being combined with potash or soda, or in the state of soluble phosphate of lime, is of the very highest importance as manure; and we ought no longer to omit, in the estimation of the value of guano, the fact that it does contain so con-

siderable a proportion of phosphoric acid readily soluble in water. Guano, in fact, in addition to the large quantity of nitrogen it furnishes, is of the nature of superphosphate of lime. I have found that the phosphatic varieties of guano also contain soluble phosphates; and hence, no doubt, their immediate action as turnip manures.

With the average composition of guano before us, it may be worth while to calculate what would be its cost if the various ingredients were supplied from other sources. Taking its actual price, we shall then be in a position to ascertain at what cost they are really bought in this manure.

Ammonia	$16\frac{1}{2}$	tons, at 68*l.* per ton (its cost in sulphate)	£1,122
Organic Matter	52	tons, at 1*l.* per ton	52
Potash *	$3\frac{1}{2}$	,, at 31*l.* ,, ...	108
Insoluble Phosphate of Lime	23	,, at 7*l.* ,, ...	161
Soluble Phosphate	7	,, at 32*l.* ,, ...	224
			£1,667

or about 16*l.* 10*s.* per ton.

Now, as the importer's price for Peruvian guano is 11*l.* per ton, it is obvious that all the ingredients will be bought at as nearly as possible two-thirds of the prices named; hence the prices which I have given in the Table for phosphate of lime and ammonia, as supplied by Peruvian guano.

If, however, it appears clear that guano is a cheap manure, even at the high price which it has now reached, it must be remembered that its use is attended with the disadvantage that, as a compound manure, the purchaser may obtain what he does not require. In sulphate of ammonia he buys ammonia only, and in mineral superphosphate, and in sulphate of potash, he may obtain either of the ingredients which he wants precisely as he requires them. In guano he has no choice, but must take the mixture as he finds it. It would, therefore, be a mistake to endeavour to put upon the ingredients of guano the price which they bear in other forms, a circumstance which the importers will do well to consider.

I now proceed to tabulate the analyses of a number of samples of superphosphate of lime, which have been received in the laboratory since the year 1852. I shall not attempt to group them in any relation to their composition, but shall present them as a faithful record of the very varying character of this manure as met with in the market. I should observe that many of the samples have been sent to me by manure dealers, and may, therefore, be taken to represent their immature attempts in the manufacture of this manure.

* The percentage of potash is taken from my early analyses. We are not in the habit of determining the proportion of this ingredient of guano, and the quantity is therefore not given in the preceding analyses.

TABLE IV.—Analyses of Superphosphate of Lime (commencing with the year 1852).

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia.	Sand, &c.	Biphosphate of Lime.	Equal to Soluble Phosphate.	Insoluble Phosphate.	Hydrated Sulphate of Lime.	Alkaline Salts.	Nitrogen.	Equal to Ammonia.
1	17·85	3·42	6·54	6·42	9·47	20·52	44·39	0·86	0·47	0·58
2	16·09	14·56	11·30	0·41	0·61	13·00	37·27	7·37	1·51	1·83
3	10·84	2·83	7·70	10·66	15·73	13·62	44·96	9·39	0·64	0·77
4	14·20	14·51	15·29	0·27	0·40	14·41	34·03	7·29	1·41	1·71
5	15·23	18·76	13·32	0·48	0·71	15·98	29·26	6·97	2·05	2·48
6	15·56	18·73	13·78	0·81	1·20	15·03	30·80	5·29	1·50	1·82
7	23·54	11·26	8·65	3·97	5·85	14·01	35·16	3·41	1·36	1·65
8	24·03	8·91	7·98	4·86	7·16	16·05	38·17	..	0·91	1·10
9	20·68	6·70	5·96	10·87	16·04	7·35	40·09	7·55	0·32	0·35
10	7·56	10·06	3·85	13·22	19·50	29·73	34·36	1·22	1·07	1·29
11	10·22	12·90	9·18	10·65	15·71	12·35	43·66	1·04	0·88	1·07
12	15·48	14·66	9·96	7·08	10·45	10·34	39·62	2·86	0·46	0·56
13	9·82	12·48	10·87	7·06	10·41	13·26	44·19	2·32	0·52	0·64
14	9·51	27·14	7·64	5·79	8·54	7·76	41·60	0·56	1·17	1·42
15	14·00	25·30	12·60	8·27	12·20	..	37·47	2·36	2·52	3·06
16	19·10	12·06	1·52	5·69	8·40	..	59·28	2·35	0·68	0·82
17	5·15	22·35	10·76	7·28	10·74	8·94	38·72	6·80	2·11	2·56
18	8·99	12·76	11·52	4·37	6·45	17·12	42·69	2·55	1·50	1·82
19	15·27	8·98	9·20	6·19	9·14	21·73	38·43	0·20	0·46	0·56
20	16·36	16·09	9·28	6·47	9·53	13·80	37·04	0·96	1·41	1·71
21	19·24	6·78	10·17	4·82	7·10	30·20	27·64	1·15	1·38	1·67
22	3·75	21·48	8·21	10·97	16·18	9·41	41·43	3·31	1·71	2·07
23	4·06	18·39	8·27	10·32	15·21	9·06	44·22	0·38	1·92	2·33
24	4·27	17·88	8·85	11·37	16·77	5·49	47·51	1·29	1·72	2·09
25	13·10	8·75	8·15	5·49	8·10	26·76	33·00	4·75	1·07	1·30
26	14·95	7·04	6·20	10·31	15·21	14·76	41·86	4·88	0·70	0·85
27	23·69	14·59	5·85	8·58	12·65	9·83	35·96	1·50	0·86	1·04
28	4·71	21·28	10·30	8·26	12·18	12·76	34·70	7·99	1·37	1·66
29	10·13	17·66	5·35	8·81	13·00	11·33	43·49	3·23	0·88	1·07
30	14·20	12·40	9·96	2·35	3·46	24·41	36·51	0·17	0·99	1·20
31	19·63	9·09	3·17	5·50	8·10	16·43	39·64	6·54	0·66	0·80
32	15·92	10·71	8·71	11·19	16·47	3·86	47·00	2·61	0·89	1·08
33	8·68	18·91	7·47	11·53	17·00	11·61	41·52	0·28	1·20	1·45
34	13·38	10·51	6·64	9·21	13·59	22·64	32·70	4·92	0·70	0·85
35	13·33	3·97	39·55	6·66	9·82	9·53	26·10	0·86	0·06	0·07
36	17·39	3·00	6·70	12·02	17·72	18·92	35·96	6·01	0·03	0·04
37	12·21	11·27	9·05	9·78	14·42	19·49	37·68	0·52	0·77	0·93
38	16·40	11·74	5·36	11·00	16·23	15·38	39·03	1·09	1·22	1·49
39	29·41	11·43	12·91	0·51	0·76	10·73	28·94	3·57	0·96	1·16
40	21·93	5·77	6·56	9·15	13·50	9·92	42·75	3·92	0·76	0·92
41	4·99	30·40	0·91	9·65	14·24	21·71	31·66	0·68	3·15	3·82
42	14·41	10·31	6·65	3·10	4·58	24·02	35·36	6·15	0·92	1·12
43	22·36	6·86	8·23	10·15	15·10	4·04	44·87	3·59	0·46	0·55
44	15·81	5·40	5·87	10·19	15·18	10·29	50·42	2·02	0·99	1·20
45	17·46	11·21	14·11	3·65	5·39	10·69	39·13	3·75	0·88	1·06
46	19·28	5·86	6·34	7·46	11·00	17·38	40·32	3·36	2·77	3·35
47	8·14	20·21	7·90	11·11	16·38	11·72	40·92	..	4·37	5·30
48	23·71	13·35	16·70	7·67	11·32	8·24	28·13	2·20	0·95	1·09
49	15·89	12·56	27·79	0·84	1·25	15·57	22·81	4·54	2·35	2·85
50	8·41	28·57	9·36	5·76	8·50	8·40	39·50	..	4·44	5·39
51	8·90	19·72	6·91	6·53	9·63	13·37	39·77	4·80	3·20	3·88
52	16·60	10·25	4·97	5·41	7·99	18·09	43·55	1·13	1·58	1·92

Analyses of Superphosphate of Lime—*continued.*

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia.	Sand, &c.	Biphosphate of Lime.	Equal to Soluble Phosphate.	Insoluble Phosphate.	Hydrated Sulphate of Lime.	Alkaline Salts.	Nitrogen.	Equal to Ammonia.
53	9·61	7·44	8·51	13·60	20·15	10·35	49·13	1·36	0·69	0·83
54	9·54	57·70	5·01	2·84	4·20	..	8·96	15·95	3·88	4·71
55	8·44	18·93	11·26	7·32	10·80	14·62	39·43	..	2·89	3·51
56	8·40	25·75	6·63	12·34	18·20	6·91	38·78	1·19	3·54	4·29
57	5·98	26·27	5·58	12·95	19·08	12·00	36·89	0·33	3·47	4·21
58	11·43	32·26	7·00	12·42	18·32	..	35·55	1·34	5·52	6·70
59	26·49	3·85	10·26	11·62	17·13	6·60	34·82	6·36	0·49	0·59
60	22·96	14·61	4·13	13·20	19·46	8·12	33·97	3·01	1·04	1·26
61	23·82	5·30	3·68	13·41	19·77	5·27	48·52		0·40	0·48
62	3·23	23·08	8·07	9·08	13·40	15·86	38·42	2·26	2·18	2·64
63	2·95	35·45	9·52	9·91	14·61	10·50	31·67		6·06	7·36
64	18·99	6·46	5·13	7·26	10·71	14·37	43·63	4·16	0·45	0·55
65	4·21	38·13	6·40	7·01	10·34	9·12	34·36	0·77	5·45	6·62
66	13·82	22·76	3·35	12·62	18·61	8·23	38·11	1·11	1·98	2·40
67	7·04	31·30	6·61	6·51	9·60	10·93	27·27	10·34	5·34	6·38
68	3·05	8·49	4·93	9·01	13·28	7·51	66·70	0·31	1·19	1·44
69	7·05	26·99	5·53	14·79	21·68	5·47	38·99	1·18	1·79	2·11
70	19·59	14·06	2·26	10·41	15·36	1·58	52·00	0·10	0·72	0·87
71	16·98	27·65	6·18	4·97	7·33	11·47	30·28	2·47	2·09	2·53
72	8·45	4·44	2·79	7·51	11·06	7·22	68·67	0·92	1·27	1·54
73	14·98	14·61	5·73	5·54	8·17	17·70	38·36	3·08	1·25	1·51
74	25·88	4·38	4·31	11·21	16·53	2·94	50·76	0·52	0·70	0·85
75	17·78	7·81	8·55	4·26	6·28	0·83	48·77	11·80	0·69	0·83
76	13·69	15·23	5·34	5·29	7·81	1·66	53·19	5·60	1·96	2·38
77	8·20	7·57	4·26	7·81	11·52	10·34	61·69	0·13	1·01	1·22
78	15·12	16·85	2·72	11·15	16·43	1·50	51·41	1·25	0·94	1·14
79	25·88	11·60	5·70	9·84	14·31	6·74	40·17	0·07	1·41	1·71
80	5·83	21·65	5·51	8·15	12·02	19·55	39·31		2·86	3·47
81	9·18	46·55	3·31	2·34	3·46	14·20	22·08	2·34	10·64	12·96
82	15·84	18·36	6·43	4·29	6·33	16·18	36·73	2·17	1·52	1·84
83	18·26	20·06	4·52	7·22	10·55	16·37	28·00	5·57	1·57	1·90
84	18·70	8·65	5·94	2·80	4·14	5·90	44·28	13·73	0·70	0·85
85	22·82	8·85	8·82	8·20	12·09	12·39	32·21	6·71	0·65	0·79
86	9·36	48·67	1·09	6·61	9·75	20·33	12·66	1·28	5·40	6·55
87	12·46	10·73	8·75	10·07	14·86	11·42	33·42	13·15	0·90	1·09
88	16·45	34·48	6·43	2·49	3·68	24·17	14·63	1·35	3·14	3·81
89	14·07	21·02	6·28	6·75	9·95	18·06	33·04	0·78	1·71	2·08
90	16·18	8·81	5·36	10·69	15·77	12·37	43·24	3·35	0·78	0·94
91	16·01	20·02	5·00	3·35	4·95	11·58	42·32	1·72	2·96	3·59
92	14·81	11·62	2·70	11·37	16·77	1·71	49·26	8·53	2·14	2·59
93	4·46	28·76	5·49	10·56	16·16	2·29	46·63	1·81	3·84	4·66
94	7·68	24·00	4·63	16·60	24·00	5·52	41·06	0·54	3·19	3·87
95	4·22	2·09	2·93	8·28	12·20	5·35	77·02	0·11	0·65	0·78
96	20·98	42·60	2·79	6·55	9·67	0·16	26·81	0·11	4·75	5·77
97	3·08	1·56	3·47	14·75	21·75	7·25	69·89		0·33	0·40
98	4·18	1·76	3·80	10·86	16·02	0·54	78·86		0·30	0·36
99	6·03	2·72	3·05	15·22	22·45	0·93	71·47	0·58	1·58	1·91
100	22·85	12·86	3·83	7·75	11·45	12·97	37·62	2·12	0·96	1·16
101	5·82	55·23	1·14	8·99	13·26	2·81	25·09	0·92	5·09	6·18
102	26·02	17·18	7·55	7·10	10·47	12·00	29·80	0·25	0·79	0·96
103	15·50	10·86	2·95	16·63	24·52	1·29	40·25	12·52	0·60	0·73
104	11·14	4·02	11·82	6·83	10·07	26·12	39·71	0·36	0·27	0·32

Analyses of Superphosphate of Lime—*continued.*

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia.	Sand, &c.	Biphosphate of Lime.	Equal to Soluble Phosphate.	Insoluble Phosphate.	Hydrated Sulphate of Lime.	Alkaline Salts.	Nitrogen.	Equal to Ammonia.
105	11·04	11·12	9·70	8·52	12·57	11·33	48·09	0·20	1·15	1·38
106	16·08	12·29	5·07	7·63	11·25	14·59	42·75	1·59	1·50	1·82
107	7·04	25·59	12·13	7·39	10·90	3·72	41·27	2·86	1·66	2·01
108	14·68	19·64	2·32	7·00	10·31	18·32	35·75	2·29	1·39	1·68
109	15·34	30·57	7·19	1·94	2·87	20·73	19·89	4·34	3·67	4·45
110	4·03	32·64	7·67	6·70	9·88	18·65	29·99	0·32	2·71	3·29
111	10·24	26·60	2·95	5·54	8·17	4·27	34·89	15·51	4·58	5·61
112	16·40	27·74	9·13	7·46	11·01	7·05	31·83	0·39	2·90	3·52
113	19·33	3·55	4·64	6·06	8·94	32·94	31·70	1·78	0·06	0·07
114	14·95	12·16	4·70	10·33	15·23	3·50	50·44	3·92	1·41	1·71
115	12·90	14·75	2·88	8·86	13·07	10·86	46·09	3·66	1·34	1·62
116	3·94	9·10	6·68	6·36	9·39	4·41	68·83	0·68	0·73	0·88
117	11·73	12·95	6·81	5·31	7·84	4·35	44·62	14·23	0·92	1·12
118	10·31	20·55	6·06	5·37	7·92	14·45	41·97	1·29	1·44	1·75
119	15·23	5·87	9·41	5·46	8·05	18·86	41·41	3·76	0·94	1·14
120	10·36	6·33	7·75	5·60	8·27	11·56	50·03	8·37	1·46	1·77
121	9·76	10·66	3·02	22·20	32·73	1·45	52·91	..	1·30	1·58
122	20·60	10·87	3·80	13·32	19·64	10·40	40·19	0·82	0·89	1·09
123	11·43	13·21	7·61	6·72	9·92	10·35	47·26	3·42	1·38	1·67
124	17·36	0·26	7·96	9·15	13·50	24·40	40·87	..	..	..
125	21·10		6·17	5·57	8·22	8·82	40·14	18·20	0·68	0·82
126	18·93	10·16	9·93	4·21	6·22	12·43	39·95	4·39	0·66	0·80
127	5·94	15·28	8·95	4·80	7·08	19·78	35·34	9·91	1·58	1·92
128	4·85	20·13	10·26	7·47	11·02	15·67	39·21	2·41	1·46	1·77
129	22·60	6·96	8·71	5·97	8·80	14·75	31·50	9·51	0·52	0·78
130	5·92	17·71	5·52	10·22	15·08	23·26	33·99	3·38	1·22	1·48
131	17·09	2·05	6·25	7·16	10·56	13·92	48·15	5·38	0·50	0·60
132	21·53	16·52	4·57	9·61	14·17	14·31	33·46	..	0·91	1·10
133	18·89	9·12	7·25	8·29	12·24	13·80	41·68	0·97	0·53	0·64
134	15·93	1·78	12·28	6·69	9·86	12·45	47·87		0·48	0·58
135	17·73	9·16	13·34	12·54	18·49	11·79	34·44	1·00	0·08	0·09
136	12·45	14·04	5·65	9·78	14·42	9·42	40·07	8·59	0·87	1·08
137	16·54	10·83	4·61	7·33	10·80	12·99	38·81	8·89	1·06	1·28
138	3·61	16·13	7·96	3·53	5·21	33·13	31·96	3·68	1·20	1·45
139	21·57	11·59	5·97	7·40	10·92	12·64	39·97	0·86	0·39	0·47
140	3·44	7·93	9·02	5·88	8·68	29·51	37·42	6·80	0·33	0·40
141	5·77	51·11	3·19	6·19	9·13	5·01	28·73	..	1·92	2·33
142	14·66	12·44	6·66	8·84	13·03	13·04	39·49	4·87	1·06	1·28
143	2·49	11·21	2·77	11·57	17·07	23·91	48·05	..	0·27	0·32
144	13·43	31·06	6·81	9·22	13·61	9·92	29·56		1·89	2·24
145	4·77	9·71	8·10	7·76	11·45	19·92	48·52	1·22	0·33	0·44
146	14·50	10·56	7·00	11·28	16·64	7·98	47·19	1·49	0·16	0·19
147	13·05	6·18	12·30	3·58	5·28	22·67	39·76	2·46	0·43	0·52
148	4·28	23·41	7·46	8·11	11·96	20·44	36·30	..	1·10	1·33
149	11·94	1·95	10·48	8·68	12·81	5·07	61·88		0·08	0·11
150	13·10	19·43	4·13	11·09	16·35	6·60	35·65		2·10	2·55
151	1·59	14·97	7·22	4·37	6·45	17·41	54·44		1·32	1·60
152	10·00	12·01	6·45	7·67	11·31	26·67	37·20		1·02	1·23
153	21·76	7·16	20·75	10·41	15·36	8·60	31·32		0·30	0·36

Analyses of Superphosphate of Lime—*continued.*

No. of Sample.	Moisture.	Organic Matter and Salts of Ammonia.	Sand, &c.	Biphosphate of Lime.	Equal to Soluble Phosphate.	Insoluble Phosphate.	Hydrated Sulphate of Lime.	Alkaline Salts.	Nitrogen.	Equal to Ammonia.
154	10·05	0·39	8·18	7·80	11·50	13·08	57·60	2·90	0·13	0·16
155	18·42	0·50	4·19	11·42	16·84	12·72	47·77	4·98	0·15	0·18
156	26·78	17·10	4·60	7·54	11·13	12·51	31·47		0·92	1·11
157	10·80	38·75	7·42	10·91	16·10	1·23	30·89		2·21	2·67
158	18·67	15·23	6·98	5·20	7·67	19·10	34·82		1·44	1·73
159	11·30	7·59	8·20	10·09	14·89	14·34	42·34	6·14	0·52	0·63
160	10·66	7·11	1·89	25·58	37·72	• •	50·28	4·48	0·44	0·53
161	15·25	9·25	8·22	3·80	5·61	6·21	46·24	11·03	0·87	1·05
162	14·72	14·74	4·38	11·34	16·72	5·64	40·17	9·01	1·35	1·64
163	20·94	29·34	5·69	6·98	9·30	7·63	22·56	6·86	1·62	1·96
164	13·48	10·76	9·93	3·58	5·28	6·31	37·64	18·30	0·45	0·55
165	22·29	11·33	13·41	4·01	5·92	4·83	36·67	7·46	0·55	0·67
166	13·12	7·60	5·39	16·27	23·99	11·02	46·35	0·25	1·10	1·30
167	14·38	13·80	4·18	9·51	14·03	10·57	45·94	1·62	2·94	3·57
168	3·63	25·00	7·83	7·89	11·64	13·14	42·51		1·34	1·62
169	7·55	4·50	2·55	17·29	25·50	25·01	38·37	4·83	0·19	0·23
170	26·06	11·97	7·33	9·86	14·55	5·62	30·60	8·56	• •	• •
171	16·19	23·80	3·14	9·09	13·41	8·90	25·88	13·00	3·03	3·68

It would be useless to attempt to deduce from these very differing figures any mean number for the composition of superphosphate of lime, but we may arrive at important results in another way.

The proportion of soluble phosphate of lime and of ammonia being, as we have before said, of the principal importance, we may see what is the general nature of the samples in reference to these ingredients.

Of 171 specimens in the table, there are—

Containing—

Less than	5 per cent. of Soluble Phosphate	11 samples,	or 6½	per cent.
Between 5 & 10	,, ,,	49 ,,	or 29	,,
,, 10 & 15	,, ,,	60 ,,	or 35	,,
,, 15 & 20	,, ,,	40 ,,	or 23	,,
Over 20	,, ,,	11 ,,	or 6½	,,

It will be observed that the number of samples containing less than 5 per cent. of soluble phosphate is very limited, being only 6 per cent. of the whole number examined. It is right that I should mention that I have omitted from the table some samples which have been sold as "turnip manure," and have contained little or no soluble phosphate of lime. It is obvious that any mixture of rubbish may be sold as a turnip manure, and however much the buyer may in reality be defrauded by such a purchase it is not fair to consider those samples as "superphosphates of

lime." In the latter class I have included only the analyses of samples actually sold under that name and that of "nitro-phosphate." It is satisfactory to observe that of the whole number of samples not more than 60 or $35\frac{1}{2}$ per cent. contain less than 10 per cent. of soluble phosphate, and of these 12 samples will be found that contain more than 3 per cent. of ammonia, and are therefore properly nitro-phosphates—in many instances of more value than an ordinary superphosphate of good quality. We may assume, therefore, that 71 per cent., or more than two-thirds of the whole number of specimens, contain more than 10 per cent. of soluble phosphate of lime.

Of samples containing from 10 to 15 per cent. of soluble phosphate we find 60, or 35 per cent.; and between 15 and 20 per cent. of soluble phosphate, there are 40 samples, or 23 per cent.

Of those specimens that contain more than 20 per cent. soluble phosphate I take no account, as they would be sold at a proportionally higher price. It is obvious that a good superphosphate of lime will contain between 10 and 20 per cent. of soluble phosphate; and inasmuch as I find 63 samples out of 174 ranging between 12 and 18 per cent., I am inclined to adopt 15 per cent. (as I have indeed done for some years) as a fair average for a well made article. But the average proportion of samples in the market is undoubtedly below this number, being probably not higher than 12 per cent.

The ammonia varies considerably: of course we cannot expect a very high percentage of this ingredient co-existent with a large proportion of soluble phosphate, but the manure is all the better the richer it is in both; thus I may point to the samples, bearing the numbers 15, 41, 50, 56, 58, 63, &c., as likely from their composition to be very excellent manures.

Perhaps the safest plan in respect to the ammonia is to be guided by the analyses of those samples having from 12 to 18 per cent. of soluble phosphate—omitting as "nitro-phosphates" those cases where the ammonia exceeds 3 per cent. Examining the Table with this view we find 51 samples averaging 1·22 per cent. of ammonia; in a statement before given, of what it appears to me we should consider a fair good sample of superphosphate, I have taken 1 per cent. as the proportion of ammonia.

In conclusion, I would say that from my experience in the analyses of samples of superphosphate of lime, and indeed of all manures intended for green crops, I feel able to say that the manufacture of these manures is rapidly improving. Sounder information, abundant capital, free competition, and improved machinery are doing for agriculture in this respect what the same causes are found to effect in every other manufacture; and although (at page 541) I have given the analysis of what may be

called a good superphosphate, and which was probably sold at from 6*l.* to 7*l.* per ton, it may not be long before such a sample will be considered of an inferior class. Of this I am sure, that the manufacturer must cease to leave any considerable quantity of phosphate of lime undissolved, and must raise the proportion of soluble phosphate to as high a pitch as possible.

Note on the Soluble Phosphates in Guano.

In the analysis of guano it is usual to precipitate the earthy phosphates from an acid solution of burnt guano by means of ammonia. In the filtered liquid phosphoric acid is, however, still present, and in our analyses is determined as phosphate of magnesia. It is this phosphoric acid that is mentioned as "phosphoric acid in the alkaline salts." It does not, however, follow that the phosphoric acid so determined should be in the soluble state in the guano, but I have proved that it is so, and generally in the proportion stated in the analysis.

The following are determinations of the phosphoric acid actually dissolved by water from guano, and, in comparison with them, I have put the results of the usual analysis :—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Phosphoric Acid dissolved by Water	3·10	3·08	3·94	3·46	3·51	1·16
As determined by the usual analysis	2·84	4·66	3·81	3·46	4·17	3·60

In four out of six samples here given, the soluble phosphoric acid, as determined by the usual analysis, closely accords with that which water actually dissolves from the guano. On the whole, therefore, we may with tolerable safety adopt the numbers given in the table as the "phosphoric acid in alkaline salts."

XXVI.—*On Agricultural Statistics.* By C. Wren Hoskyns, Wroxhall Abbey, Warwickshire.

'Suppose a ship bound on a twelvemonth's voyage; that she cannot touch at any port short of her destination, nor by any skill of sailing shorten her passage by a day; that the number of her crew and passengers is known, and even its variation by death or birth, during the trip, ascertained with tolerable precision : what would be thought of the captain who should steer on his errand across the "trackless waste" without any knowledge of the quantity or kind of food on board—its proportion to the number to be supported, and the length of the voyage?'

Such, in substance, is the illustrative yet simple shape in which a private gentleman, uncommissioned by authority, and not at all anticipating any after-publication of his words in a folio blue

book, explains to the farmers of Suffolk the argument for Agricultural Statistics, and introduces a sort of apology for his own earnest and enlightened advocacy of the measure. An illustration is seldom fully appreciated whose obviousness outruns the sense of novelty; but it is not the less due to Mr. Peirson, the Chairman of the Framlingham Farmers' Club,* to say, that in the effort to commend a dry and seemingly distasteful subject to the favour of his hearers, he could hardly have chosen a figure, whose aptness reposed on a sounder philosophy. We *are* 'bound on a twelvemonth's voyage.' We,—consumers of earth's harvests,—are the passengers, some the crew may it be hoped, of such a ship: we touch at no half-way port, nor can we shorten the duration of our voyage. The great centre of light and heat, round which we travel, gives us but one harvest in the year—one opportunity of storing our vessel for her trip; and though (to descend from the astronomical to the national) we are able to import from other shores that supplement of our local deficiency, which the world furnishes from its spare stock; yet not one bushel of corn can we so obtain except for its equivalent in some superadded labour of our own, which still must turn its wages into food, and so become an appendix to the original demand upon the soil. In this re-active effect of imported food, the British corn-grower is presented with an annually widening margin, an enlarging front, so to speak, of customers, whose imported supplies are the true measure of an excessive demand, overtaking the produce of his own furrows: and such is, in fact, the condition of husbandry in a country requiring to import, and able to pay for, a large amount of food beyond its own annual produce.

But what is THAT? Amongst all the strange questions that curiosity or business should still have left, to ask, in a country of the busiest and best statists in the world, in the country of Domesday-Book—the oldest record of Land-statistics, it is said, in Europe, and of some of the earliest efforts ever made by a government to learn the produce of its harvests—what is more strange than that we have gone on importing corn as well as growing it, in the profoundest ignorance and apathy till the last few years, upon one of the most interesting, and, one should suppose, most primitive questions it is possible for a country to ask itself, and containing within itself the reply, to answer—What, in quantity and kind, is the food-produce of our own acres? What is the home-grown portion of that immense consumption, say of corn alone, of which the imported supplement, gathered in every quarter of the globe from fields we did not sow, has now arrived at an annual average of nearly *ten million of quarters?*

* See Reports of Poor-Law Inspectors on Agricultural Statistics (1854), p. 41.

It may be noticed, that when any subject of suddenly enlarged and recognized importance has taken possession of the public mind, there is generally a certain class of persons of the *Nîl admirari* school ready to pour oil upon the excited waters, by the assurance that there is nothing whatever new in the question; that it is as old as the subsoil of a Warwickshire ridge, and is merely turned up again to daylight after a century or two of darkness and repose. Drainage, we have now frequently to hear, is as old as the Romans; the most improved system of irrigation, merely an approach to the Saracenic model still traceable by its vestiges in Spain, or to examples to be found at still remoter depths of antiquity in Egypt or in Peru. And it cannot be denied that re-actionists of this class may find some countenance for their universal theory by a little exploration into some of the oldest existing statutes of this realm. So far indeed, from state-inquiry into the produce of the harvest, with the view of ascertaining the probable range of prices for the year, being a thing unprecedented or newfangled, it is rather to be feared that the early instances which might be quoted of inquiry and enactment connected with the sale of corn (of which the "Judicium Pillorie," a statute of the thirteenth century, is one of the most ancient *) laid the foundation of the very causes (strange as the paradox may seem) that have eventually denied to husbandry that conscious stature and development, which its world-wide reputation should long ago have made it feel and act upon in this country, in the manner exemplified by many later-grown branches of national industry, from which statistics have sprung with spontaneous growth. If our agriculture be found backward and uninformed in this department—one so fundamental for all self-knowledge, so imperative for all trade security and steadiness of dealing, it surely is not that the clouds of state-neglect have hung on it, but rather that it has been "too much i' the sun," in that regard. That some part of the answer to the question, Why are we without statistics? is to be found in this very circumstance, will suggest itself to the careful reader of our early agricultural history as recorded in the Statute-book. That rule, of daily proof throughout the whole economy of animal and vegetable nature, that where you interpose a meddling hand you arrest spontaneous action, is not less true of the more compound but still nature-governed machinery, in which the phenomena of Exchange succeed those of Production.

It is not quite ten years ago since a circumstance occurred in the corn trade of this country calculated to awaken even the most unobservant to this question. No Mark Lane prophet had fore-

* See Morton's Cyclopædia, Art. "Legislation."

told it; nor can it be said that any of that more abundant mental element in all communities, the faculty of after-wisdom, essayed to turn it to much account. Yet if such an event had happened in the iron trade, or in the cotton market of Liverpool or Manchester, we will hazard the assertion that it would not have been suffered to pass by as a mere phenomenon of the year, without being improved to future use. It was this:—During the six weeks immediately following the harvest of the year 1846, from the middle of August to the end of September, the average price of wheat was 48*s.* 2*d.*, the lowest point touched being 45*s.* 1*d.* After some improvement in the following month it fell again by the end of November to 50*s.*; by which time, most of that large, but we hope not increasing class who thresh out this year's corn to pay last half-year's rent, that class, whom the Mark Lane phraseology cruelly distinguishes as 'needy sellers,' the same class (for so unhappily it ever is), who 'cannot see what good agricultural statistics are to do,' had turned their little stock into cash and the cash over to their landlords. The year had no sooner died out than the symptoms of a scarcity began to manifest themselves, which in the course of six months brought the price of wheat, *the produce of that same* harvest (and in spite of an importation of upwards of four and a half million quarters of wheat alone), to the extraordinary price of 102*s.* 5*d.* per quarter.

Here was a prominent and melancholy instance of that law so quaintly expressed in the adage that tells us "the weakest go to the wall." Taking the actual *value* of the whole wheat crop of that year as fairly, at any rate approximately, indicated in the sum of the weekly averages of the Gazette from harvest to harvest, the small farmer who came early into market with his crop lost about 27*s.* on every quarter of wheat sold—a sum which, at the rate of four quarters to the acre, exceeded the whole cost of the fallow. Supposing his oddmark of wheat about 20 acres, his rent about 200*l.* a-year, he sacrificed the full amount of the half year's rent he was selling to meet. This is paying at a dear rate for the enjoyment of that kind of gambling which subsists solely upon ignorance, but which would, like a bet, lose even the element of fairness, would be not even justifiable, if certain *existing facts* were known which might be known, and which it is to be hoped soon will be known, equally to rich and poor, equally to the large and small farmer. It is to the latter—the man who cannot afford to wait the turns of the market,—that the statistical estimate of the coming prices of the year, based not upon guesswork, but upon the ascertained *facts* of the harvest, would be most pre-eminently serviceable. The loss even of a few shillings a quarter, when examined and duly multiplied, is a far more serious loss than meets the ear.

In the course of the year 1847, when this extraordinary culmination of prices took place, Mr. Milner Gibson, then Vice-President of the Board of Trade, introduced a Bill into the House of Commons, entitled "A Bill to make provision for the collection of Agricultural Statistics in England and Wales." Of the provisions of this Bill a short epitome is given by Mr. Bowring in his examination before the Committee of the House of Lords in July last, as follows:—

"The duty of obtaining the information specified in the schedule attached to the Bill was entrusted to the Registrar-General of Births, Deaths, and Marriages, the superintendent registrars throughout the country being charged with the appointment of 'agricultural enumerators' in their respective districts. Those enumerators were to make lists of all the occupiers of land exceeding three acres, and to send the specified blank forms to them, which were to be filled up and returned to the enumerators within fourteen days. The latter were to classify them and make general tables from them, which were to be returned through the superintendent registrars to the Registrar-General by the 10th of July in each year, for the use of the Board of Trade, who were to have power to alter the forms of the returns given in the schedules as experience might show to be advisable."

The fate of that Bill is graphically described by Mr. Bowring in his next answer (902):—

"I cannot find that it reached beyond the first reading; it never was read even a second time. One or two short discussions took place in the House on the subject. The importance of it was admitted by those who spoke, but there was not sufficient interest expressed to make the Government feel that there was any chance of passing the bill; and it was accordingly abandoned." *

Such was the end of that well-intended and well-timed effort: but while such was the feeling on the subject within the walls of the House of Commons, a small but increasing class of thinkers outside the House began from that time to view the subject very differently. The absurdity of having wheat, the produce of the same harvest, under 50*s.* a quarter in November and up at more than twice the amount in the course of six months, caused people to ask why, amidst all the returns that Government thought it desirable to have, and scientific and other societies of all kinds found it useful as well as interesting to collect and record, the only thing left unregistered and unrecorded was that important element of our annual condition,—the Produce of the Soil.

No one can look into the 'City Articles' of the newspapers during the autumn months of the year, without seeing day after day the 'prospects of the corn harvest' referred to as an item of acknowledged and impressive moment, bearing upon interests so vital as to be familiarly spoken of as the pulse of the nation; yet so vaguely, with such a mere solemn array of guesswork, at

* Report from the Select Committee of the House of Lords on Agricultural Statistics, June, 1855, p. 142.

the best, that men of business, as they put the paper down, may be heard muttering about the 'harvest' in the tone used when some baffling subject of a nature totally foreign to his habits intercepts the smooth deep current of calculation in the mind of a man accustomed to fore-calculate in everything.

In the course of his evidence before the House of Lords' Committee,* Mr. Leone Levi says,—

"I believe merchants consider it of very great importance to them, to be as early as possible made acquainted with the probable wants of the country in matters of food; because I need not say that the prices of grain have a very great influence on the prices of all other articles, and the Mark Lane Journal is the barometer by which the value of all other articles is regulated. It is also of the utmost importance to merchants, in order to regulate their speculations and their orders abroad for other articles of consumption, to be speedily informed whether we shall have abundance of grain at home, or whether we shall have to seek from foreign countries very large supplies. The influence of such uncertainty upon the Funds is always remarkable, and upon the bullion in the Bank. The possibility of having to send a great deal of gold abroad has very considerable influence on private credit, discounting bills, &c. All those transactions are very considerably affected by the uncertainty which prevails as to the result of the crops in this country.

"There are other reasons besides in favour of obtaining such statistics as soon as possible: the later we are in foreign countries for our purchases, the less chance we have to obtain the grain. Our harvest here is about two months later than the harvest in Italy or France, and it is natural that immediately these countries find their crops to be very deficient, they should at once send for supplies, and as they are nearer the Danube, from Marseilles for instance, than we are, they get their supplies provided for from the Danube, Alexandria, and other places, before almost we know ourselves that we also want them. This of course affects very materially the commerce of the country. The influence of such suddenness of rise in the price of grain, together with the rise of freight, has also great influence on the rise or on the decline of the prices of other articles of consumption here, because the more we have to pay for grain the less we have to bestow upon other articles, and that affects their value, and our relations with the countries from whom we receive such articles of luxury; our exports also are affected from the same causes, and thus it acts and re-acts in many ways. . . . I know that estimates of the harvest are constantly made by private merchants and farmers, and these are abundantly published in the Mark Lane Express and other papers; yet these estimates are generally uncertain, and are often made by interested parties. Indeed the conflicting nature of such information is often the source of considerable fluctuation of prices. . . . The farmer stands upon the same level as the merchants, because, no doubt, whilst the merchants have often to pay dearer for grain on account of their ignorance, the farmer often sells a larger quantity in the first instance at lower prices than he was justified in doing; and this is especially the case with those who being least acquainted with the general state of the country, go on selling; and, perhaps, after they have sold all they have they find that those who have been fortunate enough to hold get double for their produce. If information was more general, they would only be disposed to sell such portions as they are under necessity of selling, and that would enable them all to participate in the rise when that rise happens."

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* Report of Select Committee of the House of Lords on Agricultural Statistics, June, 1855, p. 128.

But no detailed description conveys with full success the features of a want, or the advantage of a remedy, which men have not yet had the means of practically contrasting for themselves: nor is it easy by particular instances to delineate general mischiefs, such as those resulting to agriculture from an entire ignorance of the area and amount of its own produce. It would be almost incredible to a person informed as to the commercial habits by which this country is best known abroad, but ignorant of the anomalies which cling to its agriculture, that no attempt has been made till quite recently to obtain any authentic returns of that immense portion of the national wealth annually derived from the capital, the labour, and the skill employed upon the land. In the very first paper, and one of the not least valuable published in this Journal, the late Mr. Pusey draws, from a very simple induction, the result that the permanent addition by improved farming of *a single bushel* per acre upon the general oddmark of wheat "would add to the annual income of the nation a sum of 1,200,000*l.*, representing a capital of 24 millions sterling, gained for ever to the country by this trifling increase in the growth of *one article alone* of farming produce, and that in England and Wales only." Since the time when that paper was given to the Society (March, 1839), and in no small degree aided by the constant efforts of the same accomplished mind which so ardently watched its progress, there is both reason and evidence to believe that the greatest intrinsic advancement agriculture has ever made in any country has been realised in this; while it remains to be lamented that through the want of a mere piece of recording machinery of which the Dynamometer now annually seen in our trial-yard presents so apt a symbol, the *index* is for ever lost, which would have actually chronicled and measured the change step by step, and furnished one of the most truly interesting chapters which a nation can write or read, of its own industrial history.

It is to be borne in mind that, for this country, the resource of new inclosure of land is (comparatively speaking) gone by. During that period of a nation's agricultural adolescence, when fresh inclosure is available, and which may be not inaccurately cotemporized in our case with the duration of the last war, from 1793 to 1815, statistical returns, however interesting in a general point of view to the political economist, would to a great extent, lose their strictly agricultural character. It is when the demand has covered this additional margin of supply, when the resort to new land begins to fail, and the resources of art must be drawn upon to increase the produce of the acre to which no new acre can be thrown, that the problem of improved husbandry begins

to unfold itself in an intrinsic and tangible shape; and it is difficult to stifle the too late expression of regret, that one of the first efforts of the Royal Agricultural Society was not directed to the establishment, under its own appropriate auspices, of a system of Statistical Returns, showing the actual employment of the soil throughout the kingdom,—a task for which the numbers, the distribution, and the general standing of its members, would have given it such pre-eminent advantage.

We are not to forget that at the period corresponding with this, in the last century, we had scarcely ceased to be an *exporting* country. In the twenty years, extending from 1773 to 1793, a sort of equipoise arrived, when imports and exports balanced each other with a nicety which marked the turning-point of our history as growers and consumers. From 1793 to the present time, importation, chequered in the early part of the century by the influences of war, bad harvests, and successive statutory enactments, was accompanied by immense inclosures of fresh land, upwards of five million acres having been brought under cultivation since that date. This resource substantially at an end, we have arrived at the alternative between increase of acreable produce at home, and the necessity of foreign purchase.

At such a time in the economic history of a country an annual *census* of its food-produce becomes as imperative as it is interesting, had the collection of it no other object than to ascertain, at the earliest possible moment after harvest, the ratio of the produce of the year to the known population; we cannot say 'to the known *consumption*,' because consumption being itself affected by price, is precisely one of those indeterminate elements in the problem which is the last to unfold itself, depending as it does on other causes connected in a circle with the first point we desire to ascertain. We know, for instance, that the *general* report vaguely arrived at, as hitherto, of the harvest, powerfully affects the money-market and the funds, that they in turn influence trade and manufactures, and that the activity of these (still admitting the influence of price) mainly governs the consumption of the year.

Were it our sole object then to obtain as accurate and reliable a return of the harvest as the subject allowed, instead of a mere guess-work, founded on no certain data, the immediate result would be of the utmost importance, and that primarily to the grower himself, as will presently be shown. But the novelty of the application of statistics to this branch of our national industry may seem to require some remarks on the very nature of this science as a comparatively modern, and peculiar branch of knowledge.

It is a familiar doctrine of science, that all knowledge is founded on 'induction;' that is to say, in more popular phrase, if you want to arrive at *principles* you must begin by noting *facts.* A general law upon any subject, be it what it may, is nothing more than the united testimony, *the voice* of a multitude of individual instances. It is only by the accurate collection and collation of these facts or instances that any reliable knowledge can be arrived at. Take, as an example, the case of the duration of human life: what can be more uncertain in the individual? One lives to a hundred, another dies in infancy; yet by a sort of rough observation and comparison of instances we easily arrive at the idea of an average duration, to which each man looks as to a known general law, and upon which he entirely and practically relies, though he sees it almost every day apparently contradicted in the individual cases by which he is surrounded, or which come within his knowledge. But this, confidently as we see it acted upon, is merely the first step, furnishing no definite conclusion and of no practical use. But let the inductive process be carried further; let the observation be carefully extended over a large area of population for a number of years, by accurately compiled tables of mortality; and that which seemed at first to be the very emblem of uncertainty, and in the second stage amounted only to an indefinite average, is gradually found to furnish conclusions, before unsuspected, but susceptible of the most important practical application.

Thus, in the recent Report of the Registrar General on the entire population of England, it is shown that a 'law' obtains by which it may be assumed with certainty that one person out of every forty-five living at the commencement of any year will die within that year.* A *fact* of this kind once established becomes a solid basis for calculations of the most valuable kind; amongst others those applicable to life insurance, whereby an uncertainty, irremediable at first sight, may be guarded against, in all that is of chief moment and anxiety to human feelings, by purchasing a fixed interest in a sum representing the assumed savings of a life of ordinary duration, by an annual deposit regulated in accordance with the known average, and reduced by it to the lowest point compatible with safety.

By the accumulation of individual facts, equally in other branches of knowledge, as in the instance given, a structure is found gradually to arise, endued with a firmness, stability, and symmetry of parts no more to have been anticipated from the nature of the original materials, than the architectural effect

* The departure from this law is so trifling, that in the fourteen years ending with 1851 there were only two years in which the mortality varied as far as to one in 40, against which may be put three years in which it was only one in 48.

of the most perfect building could have been fore-conceived from an inspection of the bricks or stones out of which the fabric grew.* There is something almost mysterious in the aggregate power of numbers thus accumulated and employed: we seem to recognise in it the gradual elimination of an inner soul and meaning, a sort of life-like significance, reminding one of the characteristic saying of the Greek sculptor that every block of marble contains a statue needing but the chisel of the artist to break the shell and bring it forth to daylight.

But another instance may be taken, and of a thing not less proverbially changeful and seemingly capricious—the weather. There is scarcely a practical farmer whose own continued experience is not sufficient in its way to have led him to suspect what the sustained and published observations of science have now placed beyond the reach of a doubt, viz., that changeful and uncertain as the daily skies may seem to the limited opportunities of a single observer during a single life, yet that these constant variations are all referable to a system of latent law needing only an adequately extended induction, a sufficiently broad basis of *statistical facts* to be apprehended and applied; and as uniform and inflexible in its operation as that which guides a falling apple to the ground, or keeps the seasons in their course. That very 'course' itself is but the larger and more readily apprehended manifestation of the same law, needing but two or three years for proof by observation, while hundreds of years and hundreds of observers placed at different stations of the globe might perhaps be insufficient (yet only as a question of *degree*) to arrive at a practical and *appliable* knowledge of the monthly and weekly, and daily ramifications of the great arterial system whose broader functions in the conduct of the year are patent to every eye. Yet an instance of what the statistical observation of facts has already accomplished, even in the difficult problem of the 'Law of storms' applied to actual use, occurred a few years ago on the occasion of a hurricane which visited New York, causing extensive damage to the shipping in the bay and harbour. It having been ascertained that these storms proceed in certain defined currents describing curves of known radii, or proportions, an experimental notice was forwarded by telegraph to New Orleans, upwards of a thousand miles away at the mouth of the Mis-

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* The classical reader will be reminded of the story of the pedant of Hierocles, who, having a house for sale, used to carry about with him a brick to show as a *specimen*. The point of this story, conversely taken, is not a bad illustration of the error of attempting to challenge or anticipate the *aggregate results* derivable from statistical matter when *put together*. It is no longer a mere congeries of parts or items—so many hundred thousand of bricks. It forms a new and complete whole—an edifice presenting features, and applicable to purposes, of which the contributor of the items could form little idea.

sissippi, this city being found to lie in the line of its calculated progress. In some forty hours after receipt of the intelligence, arrived the formidable visitation which the electric wires had predicted, finding every sail close-reefed of the innumerable river-craft always assembled there, every topmast ready struck, and all made safe and snug to meet the blow. Thousands of pounds' worth of valuable property was thus saved by the timely aid of a science imperfect as yet, but, so far as known, the pure offspring of statistical observation.

Everything throughout creation is governed by 'law:' but over most of the tracts that come within the active experience of mankind, the governing hand lies so secret and remote that until very large numerical masses are brought under the eye at once, the controlling power is not detected. To an appreciating mind there is something attractively beautiful in the delicacy with which laws of unswerving regularity and resistless force are withdrawn from view, masked behind an apparently inexhaustible variety, an independence and spontaneity of action, and a playfulness of 'accident,' seemingly without control or bounds. It is impossible too much to admire this indulgent feature of creative and administrative power, which permits thus its graciousness to be lost to general sight in the success of the very illusion employed. The whole vocabulary of those who talk of 'chance' and 'luck' attests the matchless lightness and elasticity of gait which disguise the majestic onward tread and movement of natural law. Statistics are the touchstone under which the illusion at once vanishes. Like some potent chemical test it 'precipitates' at once, and exposes to view, the latent law so skilfully held in solution. Gathering its facts together and employing them in masses, dealing with Nature wholesale and in the gross, meeting her upon a scale of magnitude, far indeed behind her own, yet in the right path of approach, this science forces out results that never would have disclosed themselves in detail. Figures are at once its facts, its arguments, and its conclusions: and the value of this will be felt when it is remembered that, as a general rule, *the degree of certainty in any science is proportioned to the extent to which it admits the application of* NUMBERS. All experience shows the truth of this, not more in scientific researches than in the most ordinary business of life. Their advantage, as the simplest means of expression, is indeed so obvious, that no practical man ever dreams of substituting for them the indefinite phrases so commonly used in arts less advanced. No engineer contents himself with saying that steel is harder than iron, or iron more ductile than lead, when he can express the hardness of the one or the ductility of the other, in numbers, though merely approximate.

"Had statistics," says one of the most able writers on the

subject, "effected nothing more than the substitution of *figures* for *words* they would have established a strong claim to our approbation. Nothing can be more variable or worse defined than the meaning of some words in constant use. What meaning are we to attach to such vague terms as 'sometimes,' 'occasionally,' 'generally,' 'in the majority of cases'? These terms, as every one knows, have every possible signification, and vary in their meaning with the varying disposition, and more or less sanguine character of those who use them. The 'sometimes' of the cautious is the 'often' of the sanguine, the 'always' of the empiric, and the 'never' of the sceptic: but the numbers 1, 10, 100, 1000, have but one meaning for all mankind." *

It is well known that the great science of astronomy, which predicts the moment of an eclipse or the arrival of a comet with the most prophetic truth and with an accuracy exceeding that of the most perfect chronometer, began its wonderful career by a mere numerical tabulation of the stars. It is now the most perfect of the physical sciences: all its elements, time, space, order, magnitude, velocity, are expressed by numbers; and of all its principles the most important, gravitation, the power that unites and retains in place the atoms of the whole universe, may be itself described as a numerical theory. Chemistry, which but a generation or two back was a mere empirical art, consisting of detached observations and experiments, a lumber-room of 'curiosities for the ingenious,' without order or connection, by the mere application of numerical system—the theory of *definite proportions*—sprang at once into practical form and life; its scattered members united into one intelligible whole, and became invested with the same foretelling power (applied to changes in the conditions and phenomena of matter) which is so remarkable a feature of the sciences that are based upon numbers, and which take rank in proportion as they are so.

But of all the uses and achievements of statistics, the most important lies in the discovery of general laws and their subsequent application to the secular uses of life. As our observations multiply, individual exceptions grow less important, or disappear, and *averages* take more and more the form of integral and new developed truths. It is as though a multitude of points or specks of light, each individually powerless, blended together into one broad and mensurable disc. Uncertain words, and phrases of the most variable and indefinite meaning, become substituted by actual figures, which for all the purposes of reasoning, comparison, and deduction, may be employed with a confidence only limited by the care used in collection of the

* See Dr. Guy's admirable Paper in the Statistical Society's Journal, vol. ii.

original *little facts*—little in themselves, most important in the aggregates they generate and the *capabilities* they disclose.

Those who are unused to such a mode of investigation, are little aware how much of that mastery over nature which they sometimes regard with wonder when seen in practical result—how much of the best of our applied knowledge is derived rather from an acquaintance with *numbers*, and *proportions*, and *relations*, than with the actual substance and essence of the things we deal with and reason about. Reduce gravitation to the mere expression that 'all bodies attract each other,' and what service could Astronomy render to Navigation? Convert the theory of atomic equivalents into a mere vague assertion of the combining power of certain substances, and small indeed would have been the light or benefit that Chemistry, analytical or experimental, could have conferred upon the arts.

But it would be vain to attempt to explain or enforce the value of Statistics (the most immediately practical application of numerical data) to an inquirer who asks the question of their use in the challenging tone of one who hides what he means by 'value.' You may give argument upon argument, and proof upon proof drawn from the most treasured depositories of daily experience and utility, but you *can not* give the capacity to understand arguments, or to appreciate uses, which themselves imply and presuppose that adult mental state at which a man begins to be sensible to the calls of civilization, as contrasted with the mere instincts of a physical and almost childish selfishness. The touching retort of the anti-arboricultural squire, who on being impleaded to 'do something for posterity' begged to know 'what posterity had done for him?' was unanswerable, and belongs to a class of reply that men are for ever trying their logical skill upon, but which never will meet with a successful rejoinder as long as the world endures. Practical, convincing, unanswerable evidence of disputed good, to the uninformed (but how much more to the prejudiced or the suspicious!) requires TIME for its accomplishment; and cannot be achieved at once by force of argument, or felicity of demonstration, charm it never so wisely.

Yet in truth it is far less difficult to point out, than it would be to define the limit of, the uses of Statistics to Agriculture. Irrespective altogether of the question of prices, let us only consider the chances and vicissitudes of weather, season, diseases, attacks of insects, period of maturity, effects of early or late sowing, the use of different manures—all those accidents and circumstances that constitute the everlasting matter of new problem and experiment,—we shall find them capable of sounder elucidation from statistical returns than from any isolated individual experiments, however accurately instituted and carried on. Reports of

agricultural experiments are almost proverbially lax, one-sided, and unreliable: either the scale is too small, or *the conclusion* too large; differences of soil, subsoil, climate, altitude, latitude, not made allowance for—are not these faults a byword of repressive caution amongst the agriculturists of our own day? What is the obvious remedy for the one great defect indicated in almost every case?—clearly, *breadth of experience*, an area adequate to the true evolution of the questions sought—a 'field' large enough for 'fairness and no favour'—a basis for observation, comparison, calculation, and conclusion, wide enough to build up truth on, like a pyramid, instead of tottering upon the narrow point of guess-work and opinion.

Examples might be multiplied from almost every branch of our national industry, were evidence required of the accession to the foresight and security which lie at the root of all successful business, afforded by the collection and classification of statistical facts. And when we look at what has been done for commerce, at our monthly Board of Trade tables of imports and exports, guiding the merchant and the manufacturer, at our weekly Bank returns, at the daily notices of the fluctuations and transactions in every description of stock, English and Foreign, that appears in our money-market, and at the avidity with which these data are resorted to as essential elements in the practical conduct of his business by every banker and commercial man throughout the kingdom,* it is scarcely possible, without a feeling approaching to shame, to "look upon this picture and on this," as we turn

* The anxiety for the earlier publication of the Bank returns, even by the space of a few days after the weekly accounts are made up, is vividly shown in the following extract from a letter addressed, in October last, to the editor of the *Times*, (it being understood that the publication already takes place *within three days* of the time when the account is completed;—the return ending Saturday being available for the directors the following Wednesday, and on Friday evening it is sent forth):—

"At the present time, when the Bank returns are looked forward to by the commercial community with so much interest, you would do them a great service if you would lend your powerful advocacy to induce the Bank directors to publish their returns somewhat more in the spirit of the age. According to the present regulation, the result of the week's movement in the bullion is *not known until the following Friday;* meanwhile rumours supply the place of facts, creating alarm and unsettling business.

"In the present day, when steam and the electric telegraph put us in possession, in a few hours, of latest intelligence from distant parts of the globe—when the state of the money-market in New York is known almost as soon as the state of the bullion in the Bank of England--surely it is not too much to ask of the Bank directors to depart from a plan *worthy only of the last century*, and to furnish the public *at an earlier date* with the actual state of the bullion in the Bank.

"The plan I would suggest is, that the returns, instead of being made up as now, should be made up on Wednesday evening, and published in the *Gazette* of the following Friday. The directors would be able to deliberate upon them at their meeting on Thursday before they are made public, while their early publication would tend, in times like the present, to do away with rumours which are far more injurious than the worst reality."

our eyes to what has been done, or rather left undone, for the corresponding information and security of a business producing an annual value, calculated twenty years ago at nearly *one hundred and thirty-three millions sterling*, with an invested capital stated, by the same authority, at 217,000,000*l.** What addition the last twenty years have made to these figures we may each of us venture to guess, but actual data there are unhappily none.

It will certainly appear not a little remarkable, the more closely the subject is examined, that the collection of the most complete body of agricultural statistics should ever have been regarded as a work of difficulty. The simplicity of the measurement of land, the permanence of the task once accomplished, the patent and unconcealable evidence of its crops, lying for weeks and months before the eye, together with the constant habit in the mind of every farmer of calculating the amount per acre of the growing crop, seem to suggest the question whether physical difficulty can properly be said to have ever really entered into the question. A kind of indifference, joined to incredulity as to the advantages to be obtained, a latent dread of publicity, that well-known terror of every trade and 'mystery' in by-gone days, the too long fostered tendency to look more to the price to be got per bushel in the market, than the number of bushels per acre in the field, these have helped to obstruct the path of the agricultural *census*. Nor are they unaccompanied by better grounds of reason. The whole system that has grown up in this kingdom in regard to the tenancy of land has been too much calculated to keep up, incidentally, the bargaining attitude in the mind of the occupier. It is no blame to him if he should feel that he has counsel of his own to keep. Where Leases are not *the rule*, as they are in Scotland, indeed so little predominant as to be actually unappreciated by the tenant himself (a proof only that he has not seen enough to have experienced their advantage), the rent of land is always a kind of unknown quantity in working out the problem of agricultural profits. Nothing is more difficult than the apportionment of the claims of owner and occupier in the improved produce, or productive power, of land not let for legally defined periods. Granted that farms may be held just as long, and just as happily, without leases as with them, and may descend, as on large estates they commonly do, from generation to generation. This forms no real answer, because it affords no practical security from the

* M'Culloch. Arthur Young, writing thirty years earlier, estimates the farm produce of England at the higher figure of 145,800,000*l.* One of the best authorities, Mr. Stevenson, (Art. 'England,' in the Edinburgh Encyclopædia,) states it at 131,066,000*l.*, which, though made on a different basis of calculation, comes near enough to fortify M'Culloch's estimate, given above. See his Statistical Account of the British Empire, p. 5.

liability to change arising from causes quite distinct from the *expiration of a term*, the thing which makes calculation upon a Scotch farm so much more businesslike than upon an English one, and changes altogether the sensations with which the tenant receives his landlord's congratulations upon the abundance of his crops and the improvement of his land. Examine it as we may, this lies at the root of the question; and it is difficult to see how, in the fair spirit of bargain between man and man, any occupier can be required to deliver up a statement of the improved returns of his farm unless he has sufficient security that the disclosure will not be turned against himself and those to whose support his skill and labour are primarily and naturally devoted. We are far from suggesting such grounds of apology for the reluctance to communicate the information required where no just cause for this apprehension exists, but we deprecate an inconsiderate contrast like that commonly heard between Mr. Hall Maxwell's happy latter experience in Scotland, with that of Sir John Walsham and the other gentlemen engaged with him in England. It is fair that an obvious and fundamental difference of circumstances, if it exist, should be pointed out and taken into the question; and it will be no new phenomenon in the occult relation of things if it be found that there is a natural connexion between long Leases and perfect Statistics.

There is a secret interdependence which links together things outwardly separate by an inner chain of practical truth, which may be found by those who will look for it, in agriculture and the relations of the soil, as well as elsewhere throughout a consistent creation: it is an excellent arguer, for its ultimate appeal is generally to men's self-interest in its broadest and most enlightened form. It antiquates erroneous systems underneath the very eyes of their apologists: before they have exhausted half the "*laudo manentem*" arguments, the very subject of their defence is gone. The surest intimation of its presence, and characteristic agency, is felt at that moment when men try to fasten a good thing on to a bad one, to make a true system work in the socket of a false one. Statistics (though pre-eminently the business and duty of a government to superintend) are a branch of 'useful knowledge' wont to spring of its own accord from the very life sap of a self-supporting and healthy business: like the well-known 'governor' of the steam-engine they should form a part of, and be set in motion by, *the very thing they are required to regulate*. To be beholden to Government for their suggestion and establishment, may indeed be objectionable, but the objection lies against the machine that failed to generate them of itself, and on its own account. The farmer who refuses his aid, or rather his *item*, to their collection, for the direction and benefit of his brother agri-

culturists all the country through, on the plea of 'inquisitorial,' 'centralizing,' and other word-arguments of this class, throws out unwittingly an argument of which he must be prepared to witness the recoil. To have after all compelled the Government to set in motion for us a machinery which but for our own omission we might long ago have perfected ourselves, and then to stigmatize as 'centralizing' the finger that nudges our pendulum and sets our hands to show the figures on that dial, which every member of a corn-market will hereafter consult,—which every successful manufacturer and trader around us does consult, each in his own calling, like an almanac or a weatherglass,—implies a sheer misapplication of language. In point of fact, however, the timidity or reluctance met with in some quarters to furnish the particulars required has been grounded upon a simply erroneous idea of the object of the call for them. It matters absolutely nothing whether the field be the field of this occupier or that, so that we do but learn its acreage, its crop, and its calculated produce for the year in question. Grant but this, as a simple territorial fact, under whatever tax-proof and landlord-proof incognito may be thought best, that by learning the statistics of each field we may make good our addition sum of the whole kingdom, and we will venture to predict that no harm, agricultural or fiscal, vicinal or political, shall betide the giver of such candid and hearty assistance; but on the contrary that, unless he be the most devoted and infatuated of gamblers, choosing darkness rather than light, from the end of this harvest to the beginning of the next, he shall be among the first in the community to benefit by the knowledge obtained, in being saved as far as human skill and foresight can save, from the time-wasting and distracting trouble of waiting on the fluctuation of markets instead of consulting the convenience of his own pocket and the wants of his strawyard, as to when he shall thrash, and when he shall sell, and when he shall fresh-litter the fold. It never was and never could be the true interest of the farmer to be forced into the corn-*dealing* business. It is plain that the more strictly each branch of a business is attended to the better it is for *all:* and waiting upon the vicissitudes of the corn-market is really the business of the *dealer* and not of the grower.

It will be not uninteresting, before we proceed to notice the results of the Government experiment of last year for the collection of agricultural statistics in England, to give a brief sketch of some of the earlier calculations connected with this subject. The discrepancies they exhibit will form their own best commentary.

First, as to the acreage of the United Kingdom. According to an ancient and traditional opinion, as early as the Anglo-Saxon

times, the area of England and Wales was computed at 29,000,000 of acres. "The mode of levying the revenue of the Anglo-Saxon kings," says Dr. Beeke,* "led to a more minute investigation of the extent and cultivation of their territory than has ever recently been attempted. The celebrated Domesday Book of the Norman conquerors was evidently formed on *a more ancient register of the same kind, to which it continually refers*." The acreage estimated by Gregory King, who wrote about the close of the seventeenth century, amounts to 39,000,000. The different estimates given by Grew, Templeman, Sir William Petty, Arthur Young, Halley, Middleton, and others, vary between 31,648,000 and 46,916,000 acres (!). The last, which is Arthur Young's, was actually adopted by Mr. Pitt in his estimate of the probable produce of the Income Tax. The more accurate computation made by Dr. Beeke, amounted to 38,498,572 acres. This, however, was still considerably in excess. According to results founded originally on the Ordnance survey, compared with the population returns, used by Mr. Rickman at the taking of the census of 1831, the area of England and Wales was reduced to 36,999,680 acres. At the last Census the amount is taken as 37,324,915.

In the case of Scotland, the table deduced from Arrowsmith's map, given in the 'General Report' of Scotland, states the acreage of the land, exclusive of lakes, of that part of the United Kingdom as nearly 19,000,000 acres (we give the nearest round numbers for convenience). This measurement has been adopted by the French author Lavergne in his recent work on British Agriculture, in preference to the earlier computations of Mr. Templeman, and of Pinkerton, by whom it is stated at 17,788,160 acres. The great irregularity of the geographical figure of Scotland, its numerous lakes and mountains, furnish a sufficient excuse for the difficult task of ascertaining its true area. The two most reliable authorities, M'Culloch and Porter, estimate its area, respectively, inclusive of lakes and islands, at 19,352,320, and 20,586,930 acres. The portion included in Mr. Hall Maxwell's 'Statistical Returns' is 12,613,345½ acres.

The estimates of the acreage of Ireland, whose outline presents a much less difficult problem of measurement, have, though few in number, differed very widely. The lowest was that of Sir William Petty, made in Cromwell's time, called the Down Survey, which, as far as it went, was a work of great accuracy, but omitted the greater part of the province of Connaught. This survey extends to about 17,000,000 acres. Dr. Beaufort's measurement, deduced from a collation and a correction of the best

* Observations on the Income Tax, p. 10.

county maps, states the area of Ireland at 19,436,000 acres. The table furnished by Mr. Griffith, the engineer, to the Lords' Committee on Tithe, founded partly on the Ordnance survey, and partly on other authentic data, gives the total acreage as 20,399,608 acres. The recent Statistical Returns, showing only the land under crop, do not assist in the correction of the general acreage.

We have thus an approximate total of about 77 millions of acres as the gross acreage of the United Kingdom. In the article by Mr. Pusey, in the first number of this Journal, before referred to, the *cultivated* acres are set down at 48 millions, which would leave, at that date (1838), *twenty-nine* millions of acres of waste land, more or less capable of cultivation. Mr. Pusey does not state the proportion of the figures he gives to the actual gross acreage. According to our present means of calculation, being for Ireland and Scotland almost complete, in respect of the cultivated portions (including meadow and inclosed pasture land), though for England and Wales only approximate, the account would be nearly as follows:—

	* Cultivated Acres (Arable and Pasture).
Ireland	5,700,000
Scotland	4,800,000
England and Wales, say	31,500,000
Total	42,000,000

The remaining portion may be, in round figures, stated generally thus:—

	Acres.
Woods and Plantations	2,000,000
Sheepwalk (Scotland)	7,000,000
Uninclosed Pasture (Ireland) ..	8,000,000
Peat and Red Bog (Ireland) ..	3,000,000
Other Waste, say	12,000,000
Islands	3,000,000
	77,000,000

If this distribution of the acreage be near the truth, there is nothing very surprising in the computation of Gregory King,† in 1685, that at the time when he wrote, the arable and pasture of England did not amount to much more than half the

* The term 'cultivated' applied to pasture will be understood, in its proper sense, as distinguishing that dressed and attended to from what is left in a state of nature. Its frequent application, in the narrower sense, to tillage and garden only, is a source of some confusion, occasionally, in land-statistics. The term 'land under crop' used in the Irish Statistical Tables, as including meadow and clover, is perhaps as good as any.

† Gregory King, the draughtsman, herald, political economist, and *statist*, died in 1712. See Fuller's Worthies (Staffordshire), vol. iii., p. 157.

area of the kingdom: though the value of its agricultural produce far exceeded the results of all the other branches of industry it contained. Macaulay notices that in the maps of the Itinerarium Angliæ, published by John Ogilby, Cosmographer Royal, in 1675, the roads through inclosed country being marked by lines, those through uninclosed by dots, the *dots seem very predominant.* From Abingdon to Gloucester, nearly 50 miles, there was not a single inclosure, and scarcely one from Biggleswade to Lincoln. In the drawings of English landscapes, made in that age for the Grand Duke Cosmo, now in the British Museum, scarcely a hedgerow is to be seen, and numerous tracts now rich with cultivation, and routes now exhibiting an endless succession of fertile landscape, run through nothing but heath and swamp, and warren. "At Enfield," proceeds that distinguished writer,

"Hardly out of sight of the smoke of the capital, was a region of 25 miles in circumference which contained only three houses, and scarcely any inclosed fields. Deer as free as in an American forest wandered there by thousands. The red-deer were then as common in the uplands of Gloucestershire and Hampshire as they now are among the Grampian Hills. On one occasion Queen Anne on her way to Portsmouth saw a herd of no less than five hundred. The wild bull with his white mane was still found wandering in a few of the southern forests. The badger made his dark and tortuous hole on the side of every hill where the copsewood grew thick. The wild cats were frequently heard by night wailing round the lodges of the rangers of Whittlebury and Needlewood. The yellow-breasted marten was still pursued in Cranbourne Chase for his fur, reputed inferior only to that of the sable. Fen eagles, measuring more than nine feet between the extremities of the wings, preyed on fish along the coast of Norfolk. On all the downs, from the British Channel to Yorkshire, huge bustards strayed in troops of fifty or sixty, and were often hunted with greyhounds. The marshes of Cambridgeshire and Lincolnshire were covered during some months of every year by immense clouds of cranes. Some of these races the progress of cultivation has extirpated. Of others the numbers are so much diminished that men crowd to gaze at a specimen as at a Bengal tiger or a Polar bear.

"The progress of this great change can nowhere be more clearly traced than in the Statute-book. The number of inclosure acts passed since King George II. came to the throne exceeds four thousand. The area enclosed under the authority of those acts exceeds, on a moderate calculation, ten thousand square miles. How many square miles which formerly laid waste have, during the same period, been fenced and carefully tilled by the proprietors, without any application to the legislature, can only be conjectured.

"But it seems highly probable that a fourth part of England has been, in the course of little more than a century, turned from a wild into a garden. Even in those parts of the kingdom which, at the close of the reign of Charles II., were the best cultivated, the farming, though greatly improved since the civil war, was not such as would now be thought skilful. To this day no effectual steps have been taken by public authority for the purpose of obtaining accurate accounts of the produce of the English soil. The historian must therefore follow, with some misgivings, the guidance of those writers on statistics whose reputation for diligence and fidelity stands highest. *At present an average crop of wheat, rye, barley, oats, and beans is supposed considerably to exceed thirty millions of quarters.* The crop of wheat would be

thought poor if it did not exceed twelve millions of quarters. According to the computation made in the year 1696 by Gregory King, the whole quantity of wheat, rye, barley, oats, and beans, then usually grown in the kingdom, was somewhat less than ten millions of quarters. The wheat, which was then cultivated only on the strongest clay, and consumed only by those who were in easy circumstances, he estimated at less than two millions of quarters. Charles Davenant, an acute and well-informed politician, differed from King as to some of the items of the account, but came to nearly the same general conclusions."

The very curiosity excited by these wild and picturesque glimpses of the bygone agricultural aspect of our country might well admonish us of the deep interest of the task which it is now proposed to undertake. Again and again the question recurs—'Why are facts like these still left in darkness?' Why, amidst all the improved means of taking the census of the population of the kingdom (a task on many grounds of far greater difficulty), and the complicated machinery required for registering the births, marriages, and deaths, together with a variety of minute points relating to the condition of the people—has it been assumed as impracticable or less important to ascertain the annual produce of the soil?

Compare for a moment the relative difficulty as connected with the subject matter of the two operations. The units of the population are moveable, and a large proportion of them may never be found in the same place two years in succession; those of the agricultural statist on the contrary are fixed. The identical acre once entered in the table of the enumerator remains the same for ever. A hedge or two may be taken away (simplifying rather than complicating the task), or the arable be converted into pasture, or *vice versâ;* but there it remains recognisable by the same observer from year to year, and all he has to do is to note the different dress it wears; even this change of habiliment, to a person tolerably cognizant of the practice of the neighbourhood, may, in the great majority of cases, be predicted before it is made, and denotes after all but a limited wardrobe. The barley-field of last year slips insensibly into the clover-field of this; the bare fallow will have covered its nakedness with a wheat-crop, and the bright-eared lammas, "making the green one red," will be waving over the recent well-manured clover ley; the costly activity of the turnip field, fed off in winter, will have subsided into the bearded whisper of the barley-crop, or, on heavier soil, beans will be found upon last autumn's partridge-stubble. The catalogue of *aliases* is so simple that the rawest Bow-street recruit would have it by heart before the end of his first day's rounds. And this once done is done for ever. Each succeeding year may bring more accuracy of measurement, more nicety of detail, a more time-cautioned estimate of produce, or of the

ultimate yield; but while the task becomes lighter, the results grow yearly more reliable, and more practically useful as the elements of a calculation that shall subserve the interests not of one class alone, but of every member of the state.

But to proceed. The first Inclosure Act appears to have been passed in 1710. There seem however to be no accurate returns of the quantity of land enclosed in the early part of that century. A committee of the House of Commons was appointed in 1797 to inquire into this subject: from their report it would seem allowable to estimate the quantity of land inclosed during the last century at about four millions of acres.

The progress of Inclosure during the present century will be more accurately seen in the following table:—

		Inclosure Bills.		Acreage.
1800 to 1810	....	906	....	1,657,980
1810 to 1820	....	771	....	1,410,930
1820 to 1830	....	186	....	340,380
1830 to 1840	....	129	....	236,070
1840 to 1850	....	66	....	369,127

The exception to the decreasing scale noticeable in the last figures of the acreage column is explained by the fact that under the General Inclosure Act passed in 1835, about 274,000 acres were, through the facilities thereby afforded, finally added to the arable and pasture of the kingdom.

Petty additions are still being continually made, no doubt considerable in the aggregate; the mere eradication of useless hedgerows is an increase not to be overlooked: still it will be seen by any one casting his eyes down these figures that the declining scale presented by the five decades of years, phlanged at the bottom by that final swoop added by the Inclosure Commissioners, tells an unmistakeable tale.

Let us now see the ratio which these fresh acres bear to the new mouths to be fed, as the century advanced. The next table will show this at once: but to make the return more complete, we will add the amount of wheat (and wheat-flour as wheat) imported during the respective periods:—

		Acres Inclosed.		Wheat Imported. Quarters.		Increase of Population (Great Britain).
1800 to 1810	....	1,657,980	....	6,009,468	....	1,506,687
1810 to 1820	....	1,400,930	....	4,585,780	....	1,978,523
1820 to 1830	....	340,380	....	5,349,927	....	2,161,495
1830 to 1840	....	236,070	....	9,076,379	....	2,249,648
1840 to 1850	....	369,127	....	23,298,353	....	2,308,181

Hence it appears that the ratio of the new land to the new inhabitants during the century has been about *four million* of

acres to about *ten million* new claimants.* "It is one of the obvious physical effects of the increase of population, that the proportion of land to each person diminishes; and the decrease is such, that within the last fifty years the number of acres to each person living has fallen from 5·4 to 2·7 acres in Great Britain, from 4 to 2 acres in England and Wales. As a countervailing advantage, the people have been brought into each other's neighbourhood; their average distance from each other has been reduced in the ratio of from 3 to 2; labour has been divided; and the quantity of produce, either consisting of, or exchangeable for, the necessaries, conveniences, and elegancies of life, has, in the mass, largely increased, and is increasing at a more rapid rate than the population." †

By a similar calculation Mr. Porter shows a reduction of the *cultivated* land in the same period, from two acres to an acre and two-thirds to each individual, and that the same quantity of land which supported less than 4000 inhabitants at the beginning of the century now supports 6000. By how small an amount of additional *labour* this increased production has been effected will be seen from the fact that while the total number of families in Great Britain increased between 1811 and 1831 at the rate of 34 per cent. the number engaged in agriculture increased only 7¼ per cent.‡

But there is another feature to be noticed, necessitating the contemplation of one more table of figures, and that is the progress of the average *price* of wheat during this period. While the resource of new inclosure was steadily diminishing, population increasing, importation affording on an average of the period of the half-century not more than *three weeks' consumption* in the year,§ (calculated by Mr. Porter on the ratio of one quarter per

* See the Statement by Mr. W. Couling, C.E., drawn up for the Select Committee of the House of Commons on Emigration, 1827.

† 'General Results of the Census, 1851.'

‡ Porter's 'Progress of the Nation,' ch. i. p. 161.

§ See a very interesting calculation, showing this result, in Porter's work, ch. i. p. 140. A cause of frequent error amongst our statistical writers exists in the use of the word 'Kingdom,' which is sometimes put for 'England,' sometimes for 'England and Wales,' sometimes for 'Great Britain' (which adds Scotland), and sometimes for the "United Kingdom" (which comprehends Ireland). It is difficult, even in the late Mr. Porter's valuable work, to distinguish always which is meant; and some of the calculations can hardly be reconciled with the *apparently* intended area. In a letter which appeared lately in the 'Mark Lane Express,' attacking with some asperity the estimate of last year's wheat crop published by Mr. Caird, the writer gravely proceeds to show the "irreparable injury done to society" in Mr. Caird's figures, by applying his calculation, made after "travelling through the entire island from the Solent to John o'Groat's," to "the population, on the census of 1841, of *the United Kingdom.*" Mr. Caird having set the example by putting down these words opposite an estimate stated as "the result of individual inquiry, &c., through the wheat-growing districts of *Great Britain,*" to which alone his estimate of 13½ million

head per annum,) the history of the average prices is most striking. Keeping the war period from 1800 to 1815 by itself, as not affording separable conclusions, and the remaining five years of the second decade in its proper place, we have the following remarkable range:—

		Price of Wheat per Quarter.
1800 to 1815 (inclusive)	.. ..	84*s.* 9*d.*
1816 to 1820 „	.. ..	78*s.* 4*d.*
1821 to 1830 „	.. ..	58*s.* 3*d.*
1831 to 1840 „	.. ..	57*s.* 0*d.*
1841 to 1850 „	.. ..	56*s.* 0*d.*

Here in spite of all the causes apparently adverse to such a result, we have a regular decline of price, betokening, from a striking point of view, an *increase of acreable produce* of the most surprising extent.

We have taken account of the two causes whose interference could alone affect this conclusion—Inclosure and Importation; we have shown that the first, compared against the population-table, has exhibited a *diminished* area per head, and the average supply by the latter has been stated at *three weeks' consumption* out of the year. In the teeth of these facts this steady reduction of price throughout the period is a striking evidence of the progress of agricultural skill. It now remains to attempt the bold task of calculating, from the foregoing data, what was the probable *average home-produce* of wheat in Great Britain during each of these decennary periods from the commencement of the century. Deducting from the calculated consumption the quantity imported, the account will stand as follows:—

		Average Annual Produce of Wheat.
1800 to 1810 (last year inclusive)	.. ..	8,152,135 quarters.
1810 to 1820 „	.. ..	9,501,457 „
1820 to 1830 „	.. ..	11,077,552 „
1830 to 1840 „	.. ..	13,359,083 „
1840 to 1850 „	.. ..	15,142,055 „

This table makes no pretension to strict accuracy: neither does it attempt to mark the *annual* progressive increase. It is merely a broad result forced out by figures placed against figures, for the whole decennary periods each taken in the aggregate, but wanting some of the requisite data for even approximate statistical exactness. On this point we are yet to seek: and we will ask the reader to follow us in a brief survey of what has actually been done during the last two or three years by the Government towards the attainment of this national object. It is hard journey-

quarters could apply, taking the acreage of the Scotch Returns, and the "proportionat total" for England (to which his second letter refers, as the basis of his calculation), at the average of 3½ quarters per acre.

ing through 'Blue books;' but we shall endeavour to save our fellow-traveller unnecessary tedium, in pointing out what is most worth his notice.

The first, chronologically taken, is Mr. Hall Maxwell's 'Report of *the Highland and Agricultural Society of Scotland* to the Board of Trade, on the Agricultural Statistics of Scotland for 1854.' Mark well the title. Here we have an Agricultural Society in its true place and doing its true work. Having through half a century's seniority over our own, affiliated and attached to itself all the local Agricultural Societies of Scotland, partaking and assisting in the arrangement of their exhibitions, contributing to their prize lists, acting in every way as an auxiliary and diffusive power, it has earned for itself the confidence and the position to be able to afford at once a prompt and effective aid to Government in a work especially needing the aid of local influence. In the person of its secretary, Mr. Hall Maxwell, the precise article was found which in England we have not,—a sort of Agricultural Chancellor whose writ would run everywhere, whose position made him recognised from one end of Scotland to the other, as a safe medium for the farmer; somebody whose recommendation might be trusted by them, and whose agency could on the other hand be securely relied on by the Government. Here indeed is 'centralization' it is true, and of a very pleasant, healthy-grown description. In England we have a specimen of the exactly opposite kind, one of the most unpopular, and not the less because most undeservedly so, of modern institutions, in the Poor Law Board. As ill luck would have it, this was the destined alembic through which our first essay in Agricultural Statistics in England was to pass. As a mere association of terms and ideas, nothing could, we repeat, be more unlucky. Association of idea is not a very logical entity, but it is one which owes terrible power to its very irrationality: for its effect, "more swift than meditation," "outrunning the pauser, reason," appeals to the imagination and the prejudice. What machinery readier, what more exactly put together as if for the very purpose, than the 'Board of Guardians' as a shrewd statistical committee, rich in local knowledge, its able arithmetical clerk as Classifier, its relieving officer as Enumerator to deliver and return the schedules of the occupiers? But the oil was wanting to make it work, that one little potent lubricant, prestige. That fatal monosyllable 'poor,' unpopular at best, is especially dangerous in composition. It is a prejudice, no doubt, but, somehow, anything connected with Poor-law machinery has a sort of effect upon the English farmer not unlike those side glimpses of portions of the rack, through some half-open door, which the histories of the Bastile and the Inquisition bring to mind: and as to making

a return of crop and stock to the "relieving officer," the name suggested to men's fears that species of relief which would realize the grammatical paradox of the '*disjunctive* conjunction.' Measurement of acres, oddmark of crops, estimates of produce, and head of stock, very pleasant subjects for an agricultural show, are a sort of things which, chameleon-like, depend for their colour very much on the point of view from which they are looked at: and whatever the future fate of English Agricultural Statistics may be,—a triumphant one, as we entirely believe and shall presently give our reasons for thinking,—the medium of introduction was, to say the least, unfortunate.

Not such the experience in Scotland. "The Scotch farmers," says Mr. Maxwell in his Report for 1854,

"as a body, at once recognised the importance and utility of the measure, and endeavoured to support and forward it by readily and faithfully affording the information required from them; and it is due to the small minority by whom the policy of the inquiry may have been questioned, or its objects misapprehended, to state, that they, in general, waived their objections, and abstained from interfering with the success of a measure approved of by the bulk of their fellow-farmers. The exceptional instances of positive opposition and refusal have been extremely rare, and in but few of these have I experienced any difficulty in obtaining authentic information from other sources; the schedules still unreturned or unaccounted for do not amount to one-fifth of one per cent. of the number issued. I have explained in the interim Report the system of agency and correspondence established over the country, by the aid of nearly 1100 tenant-farmers, acting as enumerators of districts and as members of committee for parishes; and I cannot too highly eulogise their energy and perseverance, more particularly as, from the inaccuracy of the lists, the novelty of the measure, and the objections by which it was at first occasionally met, they were exposed to a much greater amount of personal trouble than was contemplated or will again be required. Many members of committee, indeed, mistaking the extent of their duties, went the length of ascertaining and reporting the exact acreage of all the crops in their respective parishes. This labour, though uncalled for, was far from being thrown away, as it afforded me the means of sometimes testing, and, I am happy to say, of confirming the accuracy of individual returns from the same localities. I am enabled, on my own knowledge, to speak as to the value and cordiality of the assistance generally rendered by all members of committee, especially in regard to reducing the arrear lists, while the enumerators of districts concur in representing the pains and anxiety evinced by their committees in estimating the averages of the crops."

It would seem to offer a somewhat mortifying contrast to turn now to the different picture presented by the Reports of the experiment proceeding meantime in England. "As a British farmer I feel myself disgraced" (said a Tenant-farmer, at the meeting of the Radnor and Knighton Agricultural Club, in October last, in reference to some remarks of its president, the Chancellor of the Exchequer), "that the experiment of collecting agricultural statistics has been attended with greater success in Scotland and Ireland than in England."

The view so emphatically expressed by this speaker was in the right direction; but a comparative examination of the two experiments will perhaps enable us to lighten the severity of this conclusion. Let us be as candid as possible by all means; but let us be fair to each in turn; and not allow a generous zeal to "o'erleap itself and fall on t' other side" of justice. In the first place Irish statistics, which are collected by the constabulary in that part of the empire, admirably as the task is performed by them, are quite out of all parallel.* With regard to the success achieved in Scotland, it must be borne in mind, in addition to what has already been said, that the experiment there was by no means new, as it was in England, a circumstance the immense importance of which, we confidently trust a very few months from the opening of the present year will amply prove. The fact is that, for the purpose of statistical inquiry, and looking at the proportionate areas of the two experiments, the year 1853 was for Scotland what 1854 was for England: in that year (1853) the Highland Society, which had in 1852 memorialized Mr. Henley (then President of the Board of Trade) on the subject of Agricultural Statistics, prepared a scheme, which finally came before Mr. Cardwell; and the result was that the Society was authorized to work their scheme in the three counties of Haddington, Roxburgh, and Sutherland. We will give in his own words Mr. Hall Maxwell's first experiences in the collection of statistics in Scotland:—

"I should mention, as I alluded before to the difficulties in the way, and to the objections to the measure entertained in some districts, that there was very considerable misconception at first of the objects of the inquiry, and of the uses which might be made of it; and I found it necessary to organise a system of public meetings all over Scotland; I wrote to the conveners of counties and to the chairmen of local agricultural associations; and in nearly every town south of Inverness I had a public meeting. I very often found a great deal of prejudice before-hand; but the farmers gave me a fair hearing, and received my explanations in a fair manner, and the result was always a vote of approval, and a promise of co-operation. These meetings afforded me, besides, facilities for organising my committees. Where I could not hold meetings, and had to trust entirely to correspondence, in one or two of the northern counties, the arrangements were more difficult, and have been less satisfactory, so much so that I find it will yet be necessary to go down and smooth the way in some of the northern districts. This I mean to do when I get back to Scotland."

"43. CHAIRMAN (Lord STANLEY of Alderley.)—Are the farmers generally sensible of the importance of obtaining accurate statistical returns?—The leading farmers decidedly are; and as to those who were not, the difficulty has been mainly removed by satisfying them that, whether these returns are to do them good or not, they cannot do them any harm; that the scheme is so arranged, the answers so brought out, and the reports so published, that they cannot be twisted against their interest in any matter of rent, rating, or

* See Sir Robert Ferguson's and Mr. Donnelly's Evidence. Lords' Committee, p. 74, 84.

taxation. The main difficulty to get over was to satisfy the public that Government had no ulterior view in originating the measure; that it was neither meant for Government purposes with regard to taxation, nor for landlords' purposes with regard to rental. That had to be demonstrated, otherwise the support of the farmers would not have been given."

"122. Earl CARNARVON.—I think you have stated that the disinclination on the part of the farmers to afford the information proceeded very much from a jealousy of communicating the details to their neighbours?—I meant to say, that *in* 1853 *we found there was, in some instances, such an objection to communicate the details to their neighbours as in* 1854 *induced us to let them communicate the details to me.* When I found people prejudiced against the measure, it was generally on the ground that they should not be interfered with; that it would do them no good, and possibly might do them harm; that it might be a landlords' question, with a view to raise rental, or a Government question, with a view to increasing the income-tax. The committee will appreciate objections such as these; but where there were such views originally taken up through misapprehension, they were very liberally abandoned whenever the matter was explained."

Here then are the very same grounds of objection experienced the next year by Sir John Walsham and some of the other Poor-Law Inspectors, to whom the task was consigned in England; and this too, under circumstances which render the difficulties encountered in Scotland far less to have been anticipated; since, after all, the great difficulty of farm-statistics consists, by admission on all hands, in objections which may be summed up in the fact that the thing is "new." A man may have farmed in England a good many acres for a good many years, and never have had his organs of articulation called upon to execute the stuttering achievement encountered in the word "Statistics," or his brain invited to translate or understand it. If we know anything of the humour of the English farmer, this troublesome preliminary would not quite go for nothing in the enterprise. In fact, though farming is old enough in England, statistics are new. But the "Statistical Account of Scotland" collected by Sir John Sinclair some half century ago familiarised the subject in every parish of that part of our island. It is not long since the work was undertaken afresh upon a new survey by the managers of the Society, for the benefit of the children of the clergy, to whom Sir John had generously made over the property in the work. There is not a single parish whose individual progress and improvements it does not particularise; and so striking were these that the superintending committee announce in their advertisement that "they now present not merely a new statistical account, but in a great measure *the statistical account of a new country.*" On the authority of a phrase so remarkable, one might, without any violence of antithesis, invert the remark just made regarding England, and say that in Scotland, on the other hand, farming is new and statistics are old. We proceed with the extracts from Mr. Maxwell's evidence:—

"107. Lord Monteagle.—Do not you conceive that the feeling of distrust and jealousy which may arise at the commencement of any system of procuring statistical information is likely to wear off in proportion as experience shows that the information may be given without any of the evil consequences which have been at first apprehended?—Certainly, I think that a year or two's experience, if you could once get over the difficulty, would remove such distrust and jealousy; if you could once get them to make their returns all over the country, and if they once do it readily, the repetition will have less difficulty."

"106. Chairman.—Are the committee to understand, from your answer to a former question, that you attribute a great part of the success which you have had in obtaining information from the farmers, to the fact that they have confidence in the person to whom they make the returns, and that you *might not have been so successful if the person to whom they so* sent those returns had been an officer of the Government, and not *a person connected with a society in which they had great confidence?*—That is a point upon which I would like the committee to examine some other person than myself; it is an awkward question to put to me; if I have stated that strongly, I must correct it upon perusal. The committee may judge by the fact, that *we have had no opportunity of testing that the farmers prefer sending their returns to such a person as is described in the query,* rather than to one of their own number; and it may be inferred whether they would have looked with most jealousy upon a Government official or one of themselves. I need have no hesitation at all events in saying, that *the farmers of Scotland have confidence in the Highland Society, and do not readily misdoubt the object which the Society has in view when it takes up a measure such as this; they rather infer that the object is for their advantage; therefore the secretary of that Society, if he does his duty, has facilities, perhaps, which no other person in Scotland possesses for working such a measure as this.*"

"125. Lord Portman.—Describe the connection existing between the Highland and the local societies.—The nature of the connection between those societies and the Highland Society is of old standing; the Highland Society has been about 80 years in existence, and at an early period it turned its attention to getting up and promoting local associations. With this object it established a system of local competitions, at which its premiums are competed for under the management of local associations; we thus not only assist these bodies financially, but as we regulate the competitions, their efforts are directed into proper channels, and the regulations and practice of the central society are gradually engrafted on their system. The result is, that after a long period of years, there is a great deal not only of uniformity of object, but of action, between all these local societies and the parent society. There is no part of Scotland in which we have not had districts parcelled out, and committees at work *in connection with our local shows, so that we had them to fall back upon for assistance and co-operation in conducting the statistical inquiry.* I therefore attribute the successful organization of the machinery necessary to carry out the system in a great measure to the facilities afforded by these local associations, and by our long-established and friendly connexions with them."*

Such was the early history of Mr. Maxwell's efforts, which in the following year 1854 yielded such satisfactory results. Let us now refer to a passage or two from the reports of Mr. Manwaring and Mr. Farnall, two of the Poor-Law Inspectors, who collected the Statistics in the West Riding of Yorkshire in

* 'Minutes of Evidence before the Committee of the House of Lords, on Agricultural Statistics,' p. 11. (June 19, 1855.)

1854, the *first year* of trial in that county. In his letter to the Poor-Law Board, dated January 5, 1855, Mr. Farnall says:—

"The inquiry into the Agricultural Statistics of the West Riding of Yorkshire is completed; and it appears to me that it is as perfectly and satisfactorily completed as its great importance deserved, and as my opinion of its feasibility led me to anticipate. Immediately on receiving your instructions to institute the inquiry, the necessary documents prepared for its prosecution were issued to every board of guardians in the district, and in a fortnight afterwards each of those boards had cordially resolved to co-operate in the undertaking by forming 'statistical committees,' and by appointing their clerks and other officers 'enumerators and classifiers' of their respective unions.

"At the meetings of the boards the objects of the inquiry were freely discussed and became thoroughly understood, while their importance was duly appreciated, so that my suggestions were readily carried out by the different boards, there being only four guardians in the ten unions named who expressed any dissent whatever to the measure.

"In the mean time the boards of guardians, which it was out of my power to attend, passed resolutions, I believe unanimously, to adopt the recommendations contained in a circular letter which I had the honour of addressing to their chairman.

"In most instances both landlords and tenants rendered effective assistance in the conduct of the inquiry; but I ascribe the satisfactory character of the results principally to the apt and nearly complete machinery which the boards of guardians and their officers supplied.* The influence and authority of the former, and the zeal and tact coupled with the official position of the latter, have thus enabled me to complete the collection of Agricultural Statistics for this district, and to realize the expectation which I led you to adopt in the event of such an inquiry being instituted in the West Riding."

Mr. Manwaring says,

"in all the unions, incorporations, and parishes, which were comprised in the district under my superintendence as Poor-Law Inspector, with but one exception, I met with the co-operation of the boards of guardians, which was also generally of a cordial character."

Had all the Reports proved of this complexion, the Agricultural Statistics of England and Wales would ere this have been accomplished, and the singular idea of attempting their collection through the medium of the most unpopular machinery, in every one of its departments, that has ever, in our days, been connected with the revered name of Law in this country, have been justified at least in its results. We must now, however, turn with reluctance to the other side of the picture, beginning with a passage from Sir John Walsham's Report to the Poor Law Board, describing his experience in Norfolk and Suffolk:—

"I must confess to feeling mortified that after perusing the remarkable Report of the 23rd January, in which Mr. Hall Maxwell describes the entire success of the Scotch experiment, and after adverting also to some of my own

* On Mr. Farnall's subsequent examination before the House of Lords' Committee, this passage is referred to by Lord Stradbroke, and the ground of Mr. Farnall's apparent change of opinion as to the utility of boards of guardians elicited. See *infra*, p. 589.

returns, I should yet be constrained to state that, in my own matured judgment, agricultural statistics cannot be generally collected in England, unless the completion and due return of the schedules be made compulsory on owners and occupiers by act of parliament.

"I do not, however, apprehend that such a legislative enactment would excite much if any ill feeling. The very persons whose opposition it has been found impracticable to overcome, usually coupled their refusals to furnish information with expressions significant of their readiness to give such information if asked for (as they termed it) 'constitutionally;' and from those, on the other hand, who have either done all in their power to promote the object of the legislature, or who have complied, though perhaps against the grain, with the request addressed to them, I have received multiplied assurances, almost in the very words with which the chairman of one of the largest Norfolk Unions, a gentleman of great experience, has concluded a note now before me, that 'the greater number of our farmers wish to have the system made compulsory, and till that is done no very accurate returns will be obtained.'" *

It is needless to quote passages to the same effect in the Reports of the Inspectors in whose districts lay the other counties of England and Wales in which the experiment was made: of Mr. Hawley in Hampshire and Wiltshire, Mr. Weale in Leicestershire, Mr. Graves in Worcestershire and Brecon, Mr. Pigott in Berkshire, and Mr. Doyle in Salop and Denbigh. In one of the Poor-Law Unions of Berkshire no fewer than 17 parishes out of 34 made no return, and in one the overseer refused to produce the rate-book. But a large farmer in one of the counties mentioned in Mr. Doyle's Report, seems to have been afflicted by so acute a sense of agrestial invasion at the blank sight of 'Schedule A.' that mere words were inadequate to express it. Letting fall upon the unlucky document the full measure of suspicious wrath, he divides it bodily into what Mr. Doyle describes as "*nearly* four pieces," and returns the disjected fragment indorsed as follows:—

"THE IDEA OF SUCH QUESTIONS! *WHAT NEXT?* WM. TARTE."

But why this angry astonishment and sharp suspicion? Is intelligence at so low an ebb among the shrewd sons of Scotland and of Yorkshire that they should fail to penetrate the dangers wrapped up in the folds of a statistical schedule? Surely the net is spread in vain in the sight of any bird; and if the coils and meshes, the 'miching mallecho' of mischief, be so transparent in agricultural statistics, these birds would scarcely have been the last to find it out and the first to step in.

But who could ever argue with suspicion? By its very nature it is shaped to bid defiance to the artillery of reasoning. He who attempts to answer it is like one who saws the branch he sits on. Every word he utters, every effort he makes, is fresh fuel to the fire he is striving to quench. It is the most hopelessly

* 'Reports of Poor Law Inspectors on Agricultural Statistics,' (England,) 1854.

intractable attitude of mind that man can wear towards man. Be it never so allied with the mere timidity of ignorance, it wears for the moment, with complete success, the garb of manly caution and superior knowledge. It is impossible to unmask it, because, unlike the vice of the hypocrite, it lacks the conscience that should help the moulting process from within. Innocent in its origin,—at least so far as fear is innocent and ignorance is innocent—it is the cruellest form of injustice because it assails the innocence of others without compunction, and without the after-sense that makes amends. "I 'll willingly give a return of my crops," says a farmer, *quoted* in a speech made at the Tring Agricultural Society, "if the grocer is made to return the quantity of tea and sugar he sells; the draper of his broad cloth, and so of all other trades," &c. Here is a sample (indorsed, too, by the speaker!) of the kind of argument referred to. It sounds fair to the ear; let us see how it will bear the simple exposure of clear statement. "I 'll willingly give a return of the crops I *grow*, if the grocer is made to return the quantity of tea and sugar he *sells*."

Passing by the false comparison between the producer and the retailer, was the objector, so confidently quoted, aware that every pound of tea, every hundredweight of sugar, passing through a grocer's hands, has already undergone, in most cases *twice*, the terrors of statistics?—first, for export, in India, China, Jamaica, or Mauritius, where it was grown and manufactured; and, secondly, on its entrance for duty through our own Custom-house? Does the broad-cloth argument fare better? Is not every tod of foreign wool that enters this country counted for duty, and reported? and, for that home grown, does it not constitute a part of the very problem of which, being unwisely ignorant, we are seeking the solution by the very measure against which the complainant brought it forth? Would intelligence have used, or quoted with approval, such reasoning as this? Yet there seems to have been no one to answer it; and no doubt many a man went home with a suspicion suggested, or an objection confirmed, by an argument which, only subjected to fair statement, demolishes the very objection it was used to fortify.

But one is almost thankful in such a case for the candour that will put objection into a shape susceptible of reply; for it is mere vexation to follow out the history of this experimental trial of one of the most useful measures that ever emanated from Government in the behoof of agriculture, as the tale is drearily told in the remaining Reports of the Poor Law Inspectors employed for agricultural statistics. But why *Poor Law Inspector?* is the question that keeps pressing on the mind as one reads, and recurring fresh and fresh at every page? There are few gentle-

men of higher standing or more valuable capabilities engaged in the public service than those who hold that title, and devote their legal and scientific prowess to the carrying out like faithful knight-errants the decrees, partaking scantly in the pleasures, of that sempiternal Round-table which imagination delights to picture, at Somerset-house. But what possible connection of thought was it that suggested the idea of turning their lances into reaping-hooks? By what 'discourse of reason' could the conclusion have been evolved that the fit and proper medium through which to invoke the agrestial mind of England and Wales to the nature and benefits of agricultural statistics was a body of gentlemen who either by education, habits, or official experience, were not in conscience bound to know a wheat from a barley-rick?

And still more does the question obtrude itself, why at the turn of every leaf of the Report one is compelled to knock one's head against the 'Board of Guardians?' What *has* this respectable but proverbially indurated body got to do with the matter? Did the originator of the adoption of this part of the proposed machinery ever hear the motto, "*Divide, et impera*"? If not, we venture to submit a short psychological reflection upon this text in the words used by no less an authority than Sir John Walsham in his late evidence before the Lords' Committee:—

> "Certain persons will always object to making returns. It is impossible to analyse all the motives influencing a man's mind in these matters. I have known myself—it has been within my own knowledge—that perhaps three-fourths of a certain number of farmers would make the returns *if left to themselves*; but *when they get together, say, at market*, with the other fourth, who will not hear of making any returns, the passive majority are sure to be led by the active minority to withhold the returns they might otherwise have given."—p. 38.

Our mildest experience joins in attestation of every word of this philosophy; but why stop at the market-place? for if such may be said of the green, what shall be said of the dry? If this be true of the semi-rural corn-market under the free canopy of heaven, how much more in the loaded atmosphere of that many-titled inner-chamber where, from time to time, vestry-meeting, parish-club, or other provincial noun-collective, rivals the close packing of the jury-box without its unanimity, the wrangling of the Old Bailey without its ancestral wit!

But how to reconcile with it the following, extracted from the same evidence, we confess to feel somewhat at a loss:—

> "In 1853 the President of the Poor Law Board asked me whether in my opinion agricultural statistics could be collected in Norfolk (being the county then specified) through the agency of boards of guardians. . . . . . I gave an unhesitating opinion that, through the agency of boards of guardians and their officers, agricultural statistics could be collected with less friction, and

certainly at much less cost, than by *any other means that were known to me.*"—p. 30.

Subsequently, in answer to a question from Lord Berners, whether, "if the boards of guardians were not made use of as the medium, the churchwardens should be required to make this return?" the reply given was—

"I am always rather fearful of considering other plans; I know many plans have been recommended, but on all occasions I have merely regarded myself as having been asked to state, *whether I thought agricultural statistics could be collected by boards of guardians*; I would not venture to state that agricultural statistics could not be collected by other agencies. As far, however, as I see my way, I believe that boards of guardians form an admirable machinery for collecting agricultural statistics, *and I have not looked much beyond them.*"

The disappointment expressed at the resulting experiment we have already quoted.

Nothing, however, can be more logical or candid than the terms in which the question originally proposed, and the answer given, are here defined. What was that question? It was not, 'How can agricultural statistics be *best* collected?' but, 'Can agricultural statistics be collected by boards of guardians?' To this the answer given is in that form which logicians, in their stiff but here not unapt phraseology, call the 'particular affirmative.' This Sir John Walsham admits, and even enforces. But still there is another limitation which does not seem to have escaped his attention in the first part of his evidence, though it does not reappear in his answer to Lord Berners. The question propounded to the witness was, Can agricultural statistics be collected by boards of guardians *in Norfolk?* The strictly definite answer which was given to this narrowly-defined question, appears to our humble view to have been most unfairly and illogically expanded into a wide-spread and mischievous fallacy. For, the question was not only limited to a particular county, but even to a particular person. The actual inquiry, with all ellipse and implication supplied, resolves itself in fact to this, "Could you with the aid of your influence in Norfolk, one of the most intelligent and advanced counties of England, undertake to collect agricultural statistics through the medium of boards of guardians?"

We will not offend the reader's power of inference by wasting a remark on the gigantic *non sequitur* which has been saddled upon the narrow back of the answer given to this question. We have dwelt at some length upon this point, but it is one which we have been anxious, for obvious reasons, to investigate; and if a further reason be required than those we shall proceed to give in the words of the Inspectors in other districts, we will confess to a feeling that undue force has been put upon conclusions not quite logically

arrived at, and some injustice done thereby to the common sense of the English agricultural community, by the committal of a new and important experiment to a test peculiarly liable to misconstruction, compared with the means employed elsewhere, and thus furnishing, in fact, no intrinsic proof of failure or success.

It will hardly be denied by any one that the true practical question we have to consider, is not what can or cannot be done by Boards of Guardians, or any other branch of Poor Law machinery, but what is the best mode of collecting agricultural statistics? A very short experience has been sufficient to make it clear that, for the present, at any rate, the idea of one uniform system throughout the United Kingdom, which would *à priori* have naturally suggested itself, cannot be entertained. Two different systems have already grown to maturity, varying with the different circumstances of two portions of the United Kingdom: in Ireland, the constabulary; in Scotland, the purely agricultural,—singularly dissimilar, one scarcely likes to say characteristic, media of procedure for the carrying out of a requisition so simple and elementary, and which, in its ultimate impact upon the soil and its occupier, must in one sense be identical everywhere. But upon the principle that a people is governed best when governed most according to its genius, it is, doubtless, to be concluded that, as far as Ireland and Scotland are concerned, the present system will remain. That commenced in England and Wales, with a result much less decided, we cannot but regard (though with the most unfeigned respect for the 'Resolutions' of the Lords' Committee, before which this inquiry was so admirably carried out) as open to reconsideration. The Poor Law Inspectors engaged in the task, whose experience and resulting opinion on this point are now undoubtedly entitled to weight, and yield to none in respect of the personal and experimental insight they obtained, are at issue even on the main question of the employment of the Poor Law machinery at all. Three only out of those chivalrous pioneers of this branch of agricultural civilisation, who went forth to make experiment of the Poor Law machinery, as suggested not *by* but *to* Sir John Walsham, though afterwards matured by him, viz., Mr. Hawley (Hampshire and Wiltshire), Mr. Manwaring, and Mr. Farnall (the West Riding), express any approval of the plan. Of these, the first, Mr. Hawley, though asserting his own adhesion to it, quotes letter after letter, in his Report, from gentlemen of influence among the Union authorities of the district, condemning the medium while approving the object, both in strong terms. Mr. Manwaring's opinion it is extremely difficult, though in a very short Report, to gather with exactness. He speaks of the "practicability, if not the ease, of agricultural

statistics being collected under the superintendence of the Poor Law Board;" but in another place says, "the machinery resorted to ought, in my opinion, to be considered merely provisional for the experiment"—having just before made the rather significant remark: "I may add, however, that I have no reason to doubt that the course adopted by me, viz., that of *employing independent assistance* in collecting the desired information in this Union, was upon the whole successful." Mr. Farnall's opinion we have already given *in extenso* (p. 583). The subsequent commentary upon it, contained in the following passage, in his evidence before the Lords' Committee (p. 78), is therefore somewhat surprising:—

"418. CHAIRMAN. Did you find a general disposition both on the part of the landed proprietors and the occupiers to assist you and give you all the information you desired?—I did.

"419. Did you find a similar disposition on the part of boards of guardians to assist you for that purpose?—*I obtained some assistance from them.*

"421. Is it your opinion that there might be any improvement made in the present mode of collecting agricultural statistics?—I think the areas of the Unions should still be retained as the basis of all operations, because they are so very accurately defined. . . . . When the enumerators have collected their schedules, they should be taken to the classifier, who should forward them to some central authority, who I think might be called the inspector for agricultural statistics, and he should reside in some central county of England, where he could command with the greatest facility all parts of the country.

"422. You mean that the returns when prepared should be transmitted to him instead of to the Poor Law Commissioners?—Yes, exactly so, and that he should be the person instructed to embody all the returns in one report: and afterwards he might draw up a report of the estimated yield of all grain crops and root crops in each Union.

"425. Would you not endeavour to obtain some assistance from the Guardians? Would you entirely keep them separate from the proposed inquiry?—I see no necessity for the Guardians, because the overseers themselves are fully aware of the quantity of land held by each person, the name, the gross and the net rateable value, and that is the first information we require.

"428. I see you state in your report, 'In most instances both the landlords and tenants rendered effective assistance in the conduct of the inquiry; but I ascribe the satisfactory character of the results principally to the apt and nearly complete machinery which the Boards of Guardians and their officers supplied.' How do you reconcile that with the proposition you are now making of discontinuing to avail yourself of the services of the Guardians?—I explained to all the boards of guardians that it was merely an experiment. I did not give them to understand that for the future they would be called upon to carry out this plan in its entirety. I think they quite understood that they were to try what they could then do as an experiment, and they were perfectly willing to do it upon those terms.

"429. Do you think they would object to continue their services?—I do not think the guardians themselves would object; I think they would willingly form a committee for the purpose: but the objection would be to their officers being employed, who have already sufficient to do: and I think that giving the relieving officer the appointment of enumerator would sometimes form an excuse to the relieving officer for the neglect of his proper duty, which is to devote all his time to the wants of the poor."

In the matured plan for the collection of statistics and memorandum for an Act of Parliament, presented by Mr. Farnall to the Lords' Committee, the board of guardians and Poor-Law machinery are never even referred to, and the medium proposed as classifiers and enumerators consists of the clerks of unions (in their personal capacity) and the parish overseers.

Mr. Graves (Worcestershire and Brecon) offers a sufficiently decided opinion, as follows: "I am convinced from the experience I have gained, that a complete, uniform, and speedy collection of agricultural statistics in England cannot be looked for from the employment of the executive machinery of the Poor Law *without compulsory powers*." An expression more than inferentially unfavourable, because it leaves the door open not merely to an alternative possibly present to his own mind, but wide enough also for others of which his experience as a Poor Law Inspector would not inform him. All the rest of the Inspectors express entire disapproval of the plan.

Mr. Weale (Leicestershire) says:—

"The experience I have gained in this inquiry has led me to the conclusion that it will be inexpedient to employ the same machinery for the collection of agricultural statistics, unless it is imposed on the guardians by statute. Several of the classifiers have told me that it has placed themselves and some of the guardians and other rate-payers in antagonistic positions, and occasioned feelings of irritation that may be injurious to the administration of that law which it is their first duty to see properly carried out."

Mr. Doyle (Salop and Denbigh) says:—

"The collection of agricultural statistics by means of the machinery through which the Poor Law is administered is an experiment, the extension or repetition of which I could not recommend in this district."

Mr. Pigott (Berkshire), explaining a delay of the returns, refers it to "the necessity, in accordance with the instructions, of obtaining them through the agencies of boards of guardians."

"In no county in my district," he subsequently adds, "could the experiment made by the Poor Law Board have been attempted with a greater probability of success. . . . . . I should here observe that several of the most influential landowners in various parts of the county, whilst approving generally of a collection of agricultural statistics, expressed very distinctly their opinions that the measure should emanate directly from the Government, and ought not to be mixed up with the duties of boards of guardians; and some went so far as to say, that, although they afforded their assistance on the statistical committees and otherwise upon the present occasion, they did so solely in deference to the desire of the Government and of the Poor Law Board, and in order that the experiment may be fairly tried.

"In conclusion, I think it right to submit briefly to the Poor Law Board my reasons for thinking that boards of guardians do not afford a convenient agency for the collection of agricultural statistics. As these bodies are renewed annually, it would be necessary in each succeeding year to re-open the question, in order to obtain the re-appointment of statistical committees, and a renewal of the inevitable delays in proceeding to the collection already

adverted to would necessarily be the consequence. I have found a general impression in the minds of those the most friendly to the proposed returns that a measure so important to the whole community should not be obtruded on the still more important duties for the performance of which boards of guardians were constituted, and with *which in fact it has nothing in common.* The warm discussions which almost certainly follow the first explanations of the inspectors, however carefully or fully made, tend to place all parties in a position at variance with that for which they were appointed, viz. a cordial co-operation in the systematic administration of the laws for the relief of the poor. The inspector, instead of being welcomed as an adviser and assistant, and a referee in difficult cases, is looked upon as an official advocate seeking to persuade the guardians to undertake a novel and distasteful task. The clerks and relieving officers are placed in a false position between the conflicting guardians on the one hand, and the Poor Law authorities on the other. The ex-officio guardians, including usually the chairman and vice-chairman, find themselves on this subject brought into collision with many of the working guardians; and it cannot be doubted that the exclusive devotion of a considerable portion of time to this one object greatly increases the duties of the Poor Law Inspector, and interferes with the regular performance of his duties of visitation, always difficult to adjust. Moreover, as has been shown in the case of the Faringdon and Newbury Unions, it does not at all follow that where the guardians have adopted the measure, and even appointed statistical committees, it can therefore be successfully carried out. But the chief objection which I see to the agency of boards of guardians *and of the Poor Law Board in this matter* is, that it tends to re-awaken those feelings of jealousy and distrust on the part of the former, which have now happily almost ceased to exist."

Here then is a pretty clear preponderance of opinion against the plan, not from mere indifferent persons, but from parties peculiarly qualified to judge of, and not likely to extenuate, the capacity of the machinery they are familiar with for adaptation to this new purpose; while it must be at the same time borne in mind that even the more favourable opinions of gentlemen employed in this department of the State, could not be taken as extending beyond the Aye or No of that particular machinery. The syllogism into which their answers must inevitably fall, though 'universal' if in the negative conclusion, would be only 'particular' if in the affirmative; because another system might still be immeasurably superior to that which their experiment of the Poor-Law machinery might enable them to approve.

Regarding the question from this point of view, and contrasting the limited experiment in England with the results obtained by a widely different and strikingly appropriate *modus operandi* in Scotland, it is difficult to avoid the question how much of the delay—and, in too many cases, downright opposition—experienced in some of the districts in England may be referable, after all, to the error of having adopted too easily a ready-made and tempting machinery, without being sufficiently alive to its unfavourable and even misleading associations. Every people and every class has its *cue*,—

"Intererit multum Davusne loquatur an Heros,"

and it is scarcely fair to anticipate a judgment of the part it will perform until that cue has been appropriately given. The remark of Sir John Walsham above first quoted, goes, more perhaps than the speaker was at the time aware, to the whole root of the matter. A defect of unanimity, a nucleus of opposition, appears to have been unfortunately developed into being, we might almost say created, by the too hasty adoption of a framework whose traditional unpopularity was itself scarcely extinct, but which also embodied an element of characteristic tendency to the production of that 'active minority' which, troublesome as it may sometimes seem, has been a not unuseful or despised feature of Anglo-Saxon constitution from the days of enlightened Tacitus to "the ignorant present time."

It has not formed any part of our intention to exaggerate the argument against the collection of these statistics by means of the Poor-Law machinery. The departmental view of the question is entirely out of our province or aim, which, in fact, limit themselves expressly to the point of view from which an agriculturist most naturally looks at an agricultural subject. But it is precisely in the strict indulgence of this line of thought that the question most instinctively arises in the form which our inquiry has taken, and that too under a review of events and circumstances less likely to suggest itself to the mind of any one to whom the recent history of agriculture in this country has not been a matter of congenial study and almost daily notice. There is no pursuit in which men see so little of their own aggregate advancement, or have such unfrequent and imperfect opportunities of measuring the speed or judging of the ratio of the progress made. Still there is a conscious impression now widely existing in the agricultural world, and partaken of beyond it, of great and undeniable recent change, amounting almost to a silent revolution. The unavoidably expanded sphere of action involved in the opening of the trade, the introduction and general use of artificial manures, the immense increase in the manufacture, and widely disseminated use, of improved implements, and new, powerful, and beautiful machinery, the higher tone and enlarged action of agricultural societies and even of its literature—these, which are but a prominent few of the causes that might be named, all of them intrinsically favourable to the introduction of an enlightening agency, such as a well-devised system of statistics, yet constitute a current whose pressure and direction are peculiarly inauspicious for the embarking a new system, however good, in a vessel freighted with old associations. The fate of new wine put into old bottles, if no longer a proverb will always recall a truth; and we doubt if any leading agriculturist of

the present day, having the question put to him for the first time which was put to Sir John Walsham, would not have shrunk instinctively at the suggestion of the medium proposed for this experiment, as a sort of *difficile per difficilius*, however he might afterwards be led to acquiesce in the economy and seeming convenience of the channel.

We lean to the belief that that first instinct would, in such case, have been the right one; that the seeming convenience of an old channel was mistaken; and that the newest and directest path of the statistical Enumerator to the very door of the Farmhouse, from a central statistical board even of the most provisional construction, and invested with ordinary constitutional authority, would have carried the point with a success owing much more to its relation with new than with old associations; and that the employment of persons so well qualified to assist, by local knowledge and ability, as the clerks of unions and parish overseers, would, if requisite, have been most effectually had recourse to in their separate capacity, apart altogether from the business of the Poor-Law.

One word on the question of the economy of the plan. This is one of the most indefinite elements that ever finds a place in such calculations. In matters of the nature under discussion, it scarcely can be said to possess independent existence. It is purely relative to the results. What seems economy to-day may prove to have been a wasteful error to-morrow. The simple calculation by which, in Mr. L. Levi's evidence, a loss to the nation of three millions sterling in freight and price is shown to accrue from the case taken of a delay in our purchase of foreign corn, through a few months' withheld information as to the wants left by the deficient harvest of a single year, affords, without attaching to it undue exactness, a sufficient general index of the breadth of the interest at stake regarded in its pecuniary aspect:—

"Suppose at the very last moment we should find ourselves to be in want of about five or six millions of quarters to be imported into this country in two or three months, of course the price of grain would rise enormously. Let us calculate that, owing to the suddenness of the demand, the rise might be about 6*s*. a quarter; the natural rise beyond it would have taken place if it had been known before. Then to these 6*s*. must be added also a very considerable rise in the rate of freights: for instance, I find that, during 1846 and 1847, the freight from Odessa to this country for tallow ruled from 50*s*. to 110*s*. a ton; and from the Danube, from 9*s*. to 21*s*. per quarter; and from Alexandria, from 6*s*. to 12*s*. during 1846. Now let it be admitted that, owing to the suddenness of the rise, as we must have the grain speedily brought in, the rate of freight also should rule 6*s*. a quarter higher than need be; that would make nearly 10*s*. a quarter, which, upon six millions, would prove a loss to the public of about 3,000,000*l*. sterling. And this may actually be ascribed to our finding ourselves all at once to be in want of large supplies, and that for that reason

speculation did not go on regularly from the commencement of the season to the last."*

A subject whose postulates involve annually such sums as these, whose data are the stubborn figures that represent the producing and consuming powers of eight and twenty millions of people, is surely misconceived as matter for petty calculations of expense which count by a few hundreds and thousands on the part of a nation whose disbursements in a single war are told in hundreds of millions. What do we live for? Not to feed nor to fight, it is true; yet to see that all are fed, that the first great human want is satisfied, and that, with the truest economy which foresight can devise, is surely an object as deeply important as any that can primarily engage the liberal attention of the state, even if no results of higher scientific aim depended on the inquiry. The fact is that the price of bread-corn probably approaches the nearest of any existing thing to an *ultimate measure of value.* 'What is a pound?' is a question which it is a sort of fashion to consider unanswerable: its value may depend upon a thousand relative circumstances. But a bushel of wheat is one of the stubbornest physical facts connected with the human creation. It is so much flesh and blood, and no more; so much muscle and sinew; so much labour, so much life. Against other articles of exchange it may seem to vary in value from year to year, because they vary; but in point of absolute value, in its intrinsic and unalterable relation to human necessity, to the first, the most recurring and most enduring of Nature's demands, it varies not. It is the ultimate measure of all other measures, and, however skilful, however advanced, however scientific the agriculture of any country may be considered, if it take no note of its aggregate produce, if it leave its grand result uncared for, it falls short of the full complement of duty that belongs to it in a really civilized community.

We have before us the statistical returns of the agricultural produce of America, France, Belgium, Denmark, and of Hungary, besides those before alluded to of Scotland and Ireland. That there may be much of error, of assumption, of oversight in all; that none, unless we may except Belgium and Scotland, approach nearly to what they might be, may be past a doubt. Yet the effort is manifest and general, and every state that produces a good set of statistics *increases the value of all the rest.* It is a work in which though every nation is a whole, yet, as in the compound forms of crystallography, every whole is but the complement of a greater whole. It may be reasonably

* Evidence of Mr. L. Levi before the Lords' Committee on Agricultural Statistics.

questioned whether, with a perfect set of statistics throughout the wheat-growing countries of the world, the actual price of that article might not remain without serious variation, beyond the difference of freight to the importing countries of each year. This certainly cannot be doubted, that the annual variation in the aggregate produce would be found to diminish in proportion as the area included in the calculation was enlarged.

Some pages back, allusion was made to the advantage derived in statistics from the employment of numbers. Great as this is, for accuracy of statement, or calculation, their advantage is not equally felt in attempting to convey, descriptively, ideas of large aggregates. 'A million of acres' or 'a million quarters of corn' affords a very feeble notion of the *comparative* quantity intended to be expressed; and great errors have arisen, nowhere more than in guesswork estimates of agricultural produce, from the use of numerical terms of great magnitude grown familiar to the tongue without the means of forming an adequate image in the mind, of the aggregates named. Numbers, however, afford this compensation, that they are capable of expression to the eye through the medium of geometrical form, superficial or cubical. In one of the public galleries of the metropolis we remember seeing some years ago an instance of the successful employment of the latter, in the form of a glass case about 18 inches long by perhaps 8 wide, and 6 in depth, which appeared filled *with mustard-seed.* Inside lay two little cases, models of the larger one, each about 3 inches in length, one filled with *white*, the other with *black* seeds of similar kind. It was the work of some ingenious person, who, wishing to demonstrate the idea of number by mass, undertook the laborious task of counting out the population of London, and inclosing the result, in this solid form; the two smaller cases respectively representing the mean annual average of births and deaths. The idea entombed in the words *two millions and a half**

* At the last census 2,362,236. Some idea may be afforded to the British farmer of the food required to supply the vast demand of the metropolis, by saying that if the population of Bath, Bedford, Beverley, Birmingham, Boston, Bridgewater, Brighton, Bristol, Bury St. Edmund's, Cambridge, Canterbury, Carlisle, Chester, Chesterfield, Cirencester, Colchester, Darlington, Dartmouth, Derby, Devizes, Doncaster, Dover, Durham, Ely, Exeter, Gainsborough, Gloucester, Grantham, Halifax, Hereford, Hertford, Huddersfield, Huntingdon, Ipswich, Kidderminster, Lancaster, Leamington, Leeds, Leicester, Lichfield, Lincoln, Liverpool, Manchester, Mansfield, Newark, Newcastle, Northampton, Norwich, Nottingham, Peterborough, Plymouth, Ramsgate, Rochester, Salisbury, Scarborough, Shaftesbury, Sheffield, Shrewsbury, Stafford, Stamford, Taunton, Tunbridge, Wakefield, Warwick, Whitby, Winchester, Worcester, Yarmouth, York, were *added together*, they would not make another London. So rapid is the growth of this queen of cities, that a population *equal to that of Exeter* is added to its number *every nine months;* but so overwhelmingly large is it, that this constant and progressive increase is scarcely perceived. Supposing its inhabitants to pass out by a single gate four abreast, and as close as they could walk, the evacuation of the town would occupy four days and nights; and supposing the

was perhaps never before so distinctly exhibited to the eye; presenting a solid commentary on the Horatian apophthegm—

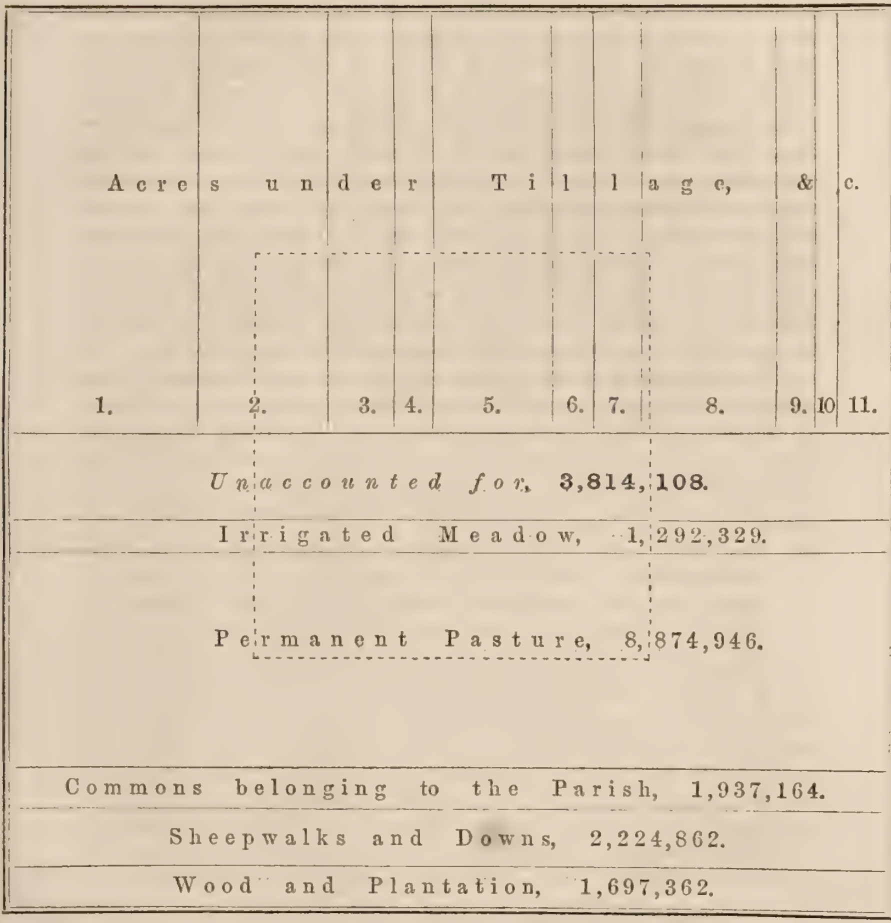
> "Segnius irritant animum demissa per aures
> Quàm quæ sunt oculis subjecta fidelibus."

We propose to make a somewhat similar experiment with the view of presenting to the reader an *agricultural statistical map* of England and Wales, in which the division and appropriation of the soil may be seen at a glance, and the proportions under each description of produce estimated by the eye, without the foggy medium of arithmetical signs. We fear the reader who looks for rivers and mountains, cities and seaports, bays and promontories, and the other usual accessories of a map, will turn away with a smile from our hydrography. Parishes, hundreds, and even county boundaries, we must here ignore. All countries are alike to the statist in form and fancy of outline. The accompanying map, then, or diagram, is constructed from the general summary of returns of agricultural statistics of England and Wales in 1854. The space over which the experiment actually extended (shown by the inner dotted square), was 7,743,850 acres, being about one-fifth of the whole acreage (37,324,915 acres, according to the last census), comprehending the West Riding of Yorkshire, Norfolk, Suffolk, Leicestershire, Shropshire, Worcestershire, Berkshire, Wiltshire, and Hampshire for England, and Denbigh and Brecon for the Principality. The counties in both seem to have been well chosen with the view of obtaining a fair average sample of the whole; and in the diagram annexed this average is assumed and applied in corresponding proportion to the whole area. It is drawn on the scale of one-eighth of an inch (running lineally across the square) for a million of acres; the arable portion being divided vertically into sections geometrically equivalent, for the better development of its less extensive areas.

The first thing that, unhappily, strikes the eye on the face of this tell-tale diagram is the broad belt crossing the centre, occupying a sort of neutral ground between the arable and pasture, consisting of nearly four million acres (about 800,000 acres in the *actual* survey), with the ominous epigraph, "unaccounted for," inscribed upon it. This, we regret to say, is mainly due to the schedules unreturned in Berkshire and Hampshire, which constitute nearly three-fifths of the whole deficiency. It will be a pleasant task, on some future occasion, to witness the diminution of this unsatisfactory *terra incognita* of refractory acres. The immense space of 'permanent pasture' forms a characteristic feature, to which Leicester, Salop, and the West Riding furnish the

march could be continuous, the head of the column, at the end of that time, would be *in sight of Edinburgh*.

STATISTICAL DIAGRAM of the AGRICULTURAL DISTRIBUTION of the SOIL of ENGLAND and WALES, on the basis of the Returns from Eleven Counties, made in 1854 (and shown by the inner dotted square).



	Acres.
1. Wheat	3,807,846
2. Barley	2,667,776
3. Oats	1,302,782
4. Beans and Peas	698,188
5. Turnips	2,267,200

			Acres.
6.	Rye	73,731	802,015
	Vetches	218,551	
	Mangold	177,263	
	Carrots	12,638	
	Potatoes	192,287	
	Cabbages, &c.	97,334	
	Flax	10,156	
	Hops	18,976	
	Osiers	1,079	

	Acres.
7. Bare Fallow	895,969
8. Clover, Lucerne, and Artificial Grasses.	2,820,066
9. Waste attached to the Farm	786,658
10. Holdings of less than 2 acres	459,447
11. Houses, Gardens, Roads, Fences, &c.	976,197

the chief contributions, amounting to more than the moiety of the whole, and suggesting something about fox-hunting.

In the arable section the large proportion of the wheat, the narrowness of the oat-crop, and the very nearly equal areas of the barley-crop and the artificial grasses, are noticeable; and the unexpectedly small proportion borne to the whole by the "holdings under two acres." The extent of the turnip-crop, reinforced by its adjoining and related section of other root and green fallow crops, constitutes an agreeable space to a farmer's eye; the 'bare fallow' being very little more than a match for this secondary assemblage of roots and green crop. The diagrams of Ireland and Scotland, which are drawn on a larger scale for the sake of more space in the smaller areas of arable, will exemplify some striking differences in the matter of potatoes and of oats respectively. But the remarks are many that would occur to different spectators, according to their bent of observation; and we shall leave our photograph to suggest its own reflections.

The subjoined table gives the produce of Scotland, comparatively, for the years 1854 and 1855:—

Crop.		1854. Acres.		1855. Acres.
Wheat		168,216	....	191,283
Barley		207,507	....	186,080
Oats		932,994	....	933,611
Rye		3,809	....	3,692
Bere (or Bigg)		18,118	....	17,260
Beans		37,702	....	37,308
Pease		6,169¼	....	5,456
Vetches		13,442½	....	15,038
Turnips		433,915¾	....	449,372
Potatoes		143,032¼	....	146,963
Mangold		1,946¾	....	2,299
Carrots		1,218	....	1,191
Cabbage		1,395½	....	1,209
Flax		6,670½	....	3,461
Turnip seed		1,429½	....	1,998
Rape		—	....	1,223
Bare fallow		26,128¾	....	22,462
Grass (alternate)		1,427,790½	....	1,509,990
Total under tillage		3,431,485	....	3,529,902
Permanent pasture	1,207,101¼	9,181,850	....	9,181,850
Irrigated meadow	69,256¼			
Sheep-walk	6,530,842¾			
Houses, roads, fences, &c.	130,538¾			
Waste	830,730¼			
Woods	413,391			
Total for Scotland		12,613,345½		12,711,752

The following is the estimated produce:—

	1854.		1855.
	Bush.		Bush.
Wheat	4,848,679	....	5,062,540
Barley	7,645,328	....	6,092,904
Oats	34,093,047	....	30,079,714
Bere	645,418	....	556,876
Beans and peas	1,081,263	....	1,183,647
	Tons.		Tons.
Turnips	6,411 419	....	6,461,476
Potatoes	529,915	....	732,141
Number of Occupants in 1855			43,462

Next come the columns of stock, furnishing the actual numbers for the whole of Scotland, in the same year:—

	1854.	1855.
Horses	166,595	177,200
Milk cows	292,365	298,446
Other cattle	438,334	469,242
Calves	205,172	207,040
Sheep and Lambs	4,787,235	5,694,737
Swine	163,683	134,349
Total	6,043,384	6,981,014

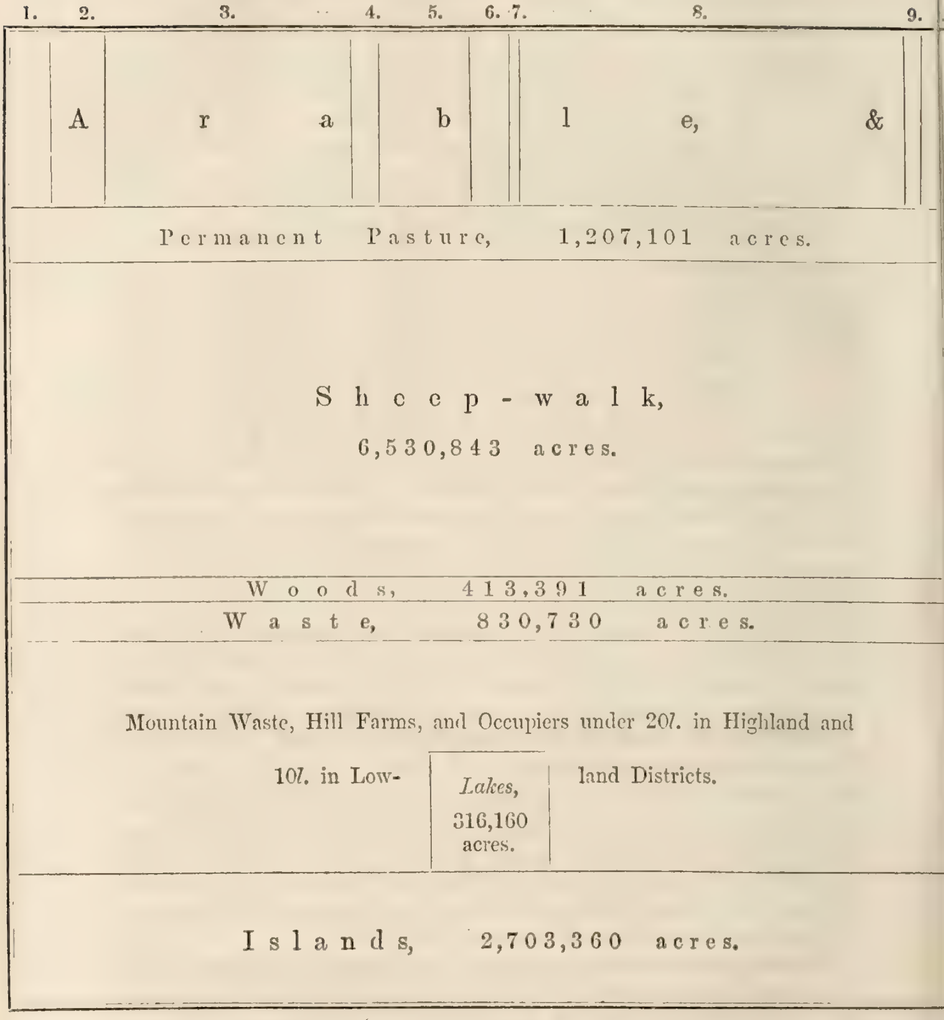
Immense as the labour it has cost to collect the matter whence these tables are framed, what can be simpler or clearer than the bird's-eye view thus given of the actual Statistics of Scotland for the two years? What a self-traced picture is here of the whole agricultural condition of this portion of our empire! Who shall attempt to define the limits of the study it presents, of the problems it suggests? Compare the turnips with the bare fallow, 449,372 to 22,462 acres; or again, the proportion of the wheat with the oats: 191,283 to 933,611 acres. What a contrast to the relative proportions of the latter crops in England! affording how interesting and instructive a lesson in the varied genius which climate exhibits, in that country of which Lavergne says "even Switzerland does not present such great obstacles to human industry; but what adds still more to this marvellous rise of prosperity upon so ungrateful a soil is, that *it is all recent.* Only a century ago it was one of the poorest and most barbarous countries in Europe: it may now be said that, upon the whole, there is not a better regulated country under the sun."*

Let us now snatch the foretaste of a task which we hope to perform for English statistics in future years, by placing side by side in immediate contrast the *figures based upon facts* above given with the guess-work Statistics of this same Scotland, given only a year or two back by the generally accurate writer just quoted. After stating that "Scotland, with its islands, contains 19 millions of acres, nearly three-fourths of which are absolutely unfit for

* Leonce de Lavergne, 'Rural Economy of England, Scotland, and Ireland,' p. 285.

SCOTLAND. [20,047,462 acres.]

Scale ¼ of an Inch (linear) to a Million of Acres.



		Acres. (1854.)
1.	Wheat	168,216
2.	Barley	207,507
3.	Oats	932,994

			Acres.
4.	Rye	3,809	91,901
	Bere	18,118	
	Beans	37,702	
	Peas	6,169½	
	Vetches	13,442¼	
	Mangold	1,946¾	
	Carrots	1,218	
	Cabbage	1,395	
	Flax	6,670½	
	Turnip-seed	1,429½	

		Acres.
5.	Turnips	433,915¾
6.	Potatoes	143,032¼
7.	Bare Fallow	26,128¾
8.	Grass in Farm rotation	1,427,790
9.	Irrigated Meadow	69,256
10.	Buildings, Roads, &c.	130,539
	Total	3,631,280

for cultivation," he divides the remainder, consisting of arable land, meadows, and 'artificial pasture,' as follows:—

	Lavergne's estimate.	Actual statistics.
Meadow and pastures	3,000,000	2,704,000
Oats	1,250,000	933,000
Barley	500,000	200,000
Wheat	375,000	180,000
Turnips	500,000	440,000
Potatoes	250,000	145,000
Bare fallow	250,000	24,000
Other crops	125,000	84,000
Total	6,250,000	4,710,000

For convenience of comparison, the second table is here given in round numbers, roughly averaged from the two years, and including under the head 'turnips' what in the previous tables appear as mangold, carrots, cabbage, and turnip seed.

Again, the following figures show the grain produce of Scotland, as estimated in 'M'Culloch's Commercial Dictionary,' and other works of authority, and the actual quantities, as ascertained by estimate in each locality for the last and previous year, stated in quarters:—

	Former Estimates.	Ascertained.	
		1854.	1855.
	Qrs.	Qrs.	Qrs.
Wheat	1,255,000	606,063	632,817
Barley	1,800,000	954,950	761,613
Oats	6,500,000	4,231,789	3,758,893
Beans and Peas	150,000	135,115	147,956
	9,675,000	5,927,917	5,301,279

The following is the average produce per acre of each kind of crop, in bushels and pecks:—

Wheat.		Barley.		Oats.		Bere.		Beans and Peas.	
B.	P.	B.	P.	B.	P.	B.	P.	B.	P.
26	2	32	3	32	$0\frac{3}{4}$	32	$1\frac{1}{2}$	27	$2\frac{1}{2}$

The root crops are stated in tons and cwts.:—

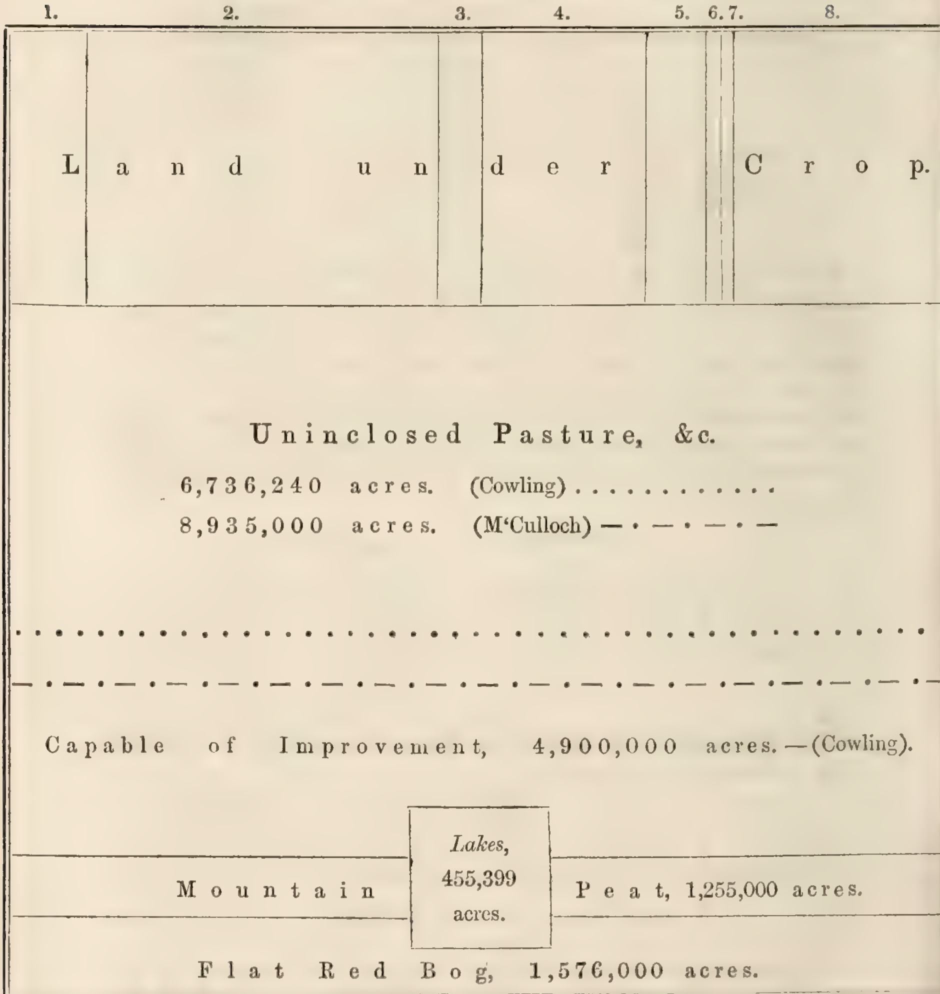
Turnips.		Potatoes.	
tons.	cwts.	tons.	cwts.
14	$7\frac{3}{4}$	4	$19\frac{3}{4}$

The variation between different counties and districts is, in some cases, apparently very great; for instance, the produce of wheat per acre is 34 bushels in Sutherland, and only 22 in Dumfries; but, on closer scrutiny, these differences are found to be more apparent than real, most of the very large yields being explainable by the fact that they refer to crops, such as wheat in the Highland counties, cultivated only on choice spots, and as a matter rather of fancy than of business.

Next follows the diagram, on the same enlarged scale, of Ireland:—

IRELAND. [20,399,608 acres.]

Scale ¼ of an Inch (linear) to a Million of Acres.



	1852.	1853.	1854.	1855.
	Acres.	Acres.	Acres.	Acres.
1. Wheat	353,566	326,896	411,284	445,509
2. Oats	2,283,449	2,157,849	2,045,298	2,117,955
3. Barley, Bere, Rye, Beans, and Peas	339,591	348,642	287,154	267,565
4. Potatoes	876,532	898,733	989,660	911,529
5. Turnips	356,790	329,377	329,170	366,497
6. Other green Crops	121,565	129,133	89,777	95,094
7. Flax	137,008	174,579	151,403	97,106
8. Meadow and Clover	1,270,713	1,280,749	1,257,864	1,311,737
Total under Crop	5,739,214	5,696,951	5,568,376	5,612,992

COMPARATIVE AREAS OR GROSS ACREAGE OF THE

UNITED KINGDOM.

LESSER BRITISH ISLES.

2,974,519 acres.

SCOTLAND.

	Acres.
Mainland	16,332,800
Lakes	316,160
Total	16,648,960

IRELAND.

	Acres.
Mainland	19,944,209
Lakes	455,399
Total	20,399,608

ENGLAND* . . . . 32,590,429 acres.

WALES . . . . . . 4,734,486 acres.

* It will be understood that the area of England extends throughout this square on which Ireland is projected.

The most striking feature observable in the statistical returns of Irish produce is the regular diminution, three years consecutively, in the total under crop. This is probably more apparent than real, in great measure arising from increased accuracy of measurement, which, as we have already seen, is apt in the collection of statistics to lead rather to reduction than increase of reported quantity.

In the preceding page is a diagram of the actual comparative areas of the several parts of the United Kingdom, in correction of the effect upon the eye of the different scales on which it has been necessary to draw them, above. In Mr. Maxwell's Statistical Returns of Scotland, the Islands are not included.

So much for the statistical returns of Scotland and Ireland. As far as these portions of the United Kingdom are concerned the task is actually accomplished, and a body of the most important evidence has been furnished, which only requires for its completeness—we might almost say, for its true utility—the performance of the corresponding task in England and Wales. Reference has already been made to the fact that in all information of this kind the relative even exceeds the positive value. In this great national Rule of THREE sum, to be without the largest and most important element of our statement, makes all effectual working of results liable to deception. The two wings of our edifice are complete: the body of the building is wanting, or at least so imperfect, that all solid calculation is at fault. It is a thing too mortifying to believe that the agriculturists of England have ever seriously declined or hesitated to perform their part in this most useful national inquiry. We would rather believe—and we do believe—that "the attempt, and not the deed, confounded us;" that the mode in which they were appealed to was erroneous. Evidence of this has been sufficiently adduced on the part of those whose admission is conclusive; leading to the conclusion that nothing is really wanting but the adoption of a system specifically suited to the end in view, and which the agriculturists, as a body, can recognise as the natural and proper channel of communication between the Government and themselves. What else was meant by the word '*constitutional?*' To our humble thinking that word contains a suggestion at once appropriate and affirmative. It seems to be pregnant with meanings that only the tongue of Englishmen can so combine, expressive at once of the love of law and of liberty, and of the resulting propriety that approves the right channel for doing the right thing; and which, done in the right way, will surely need as little of penalty or compulsion as amongst our brother agriculturists in the North. In favour of this view we need only quote what Mr. Hall Maxwell says on the same question as applied to Scotland:—

"Our strength at present lies in this, that by means of the enumerators, and the members of the committee, including a representative from every parish in Scotland, we are working out the measure by means of the farmers themselves, and we bring a weight of farming opinion and influence to bear upon the farming community which has proved irresistible, and is one of the great secrets of our success; but if we attached the collection of the acreage to any compulsory measure such as is proposed, we should alienate very many people, dislocate the committees which have been formed, and render it necessary to consider some new means of forming our estimates of produce."

He subsequently adds the following expressive notice:—

"If the measure were made compulsory in Scotland, I conceive the Highland Society would require to give up the charge of the inquiry; . . and what is more than that, I conceive the whole machinery which has been called into existence would at once cease; because farmers would not, I think, as members of the committee and enumerators, continue to act as instruments in carrying out a measure which might involve their neighbours in the penalties which a neglect of the provisions of a compulsory Act might bring upon them. I conceive that a system of compulsion in Scotland would render it necessary to organise a new and different machinery from that which is now in existence."

Throughout the instructive evidence of an admirably-selected body of witnesses * examined by the Committee of the House of Lords, from which we have quoted so much, there is not a passage that seems to contain more important reflection than the foregoing, in reference to the course to be adopted for the completion of a result so generally desired as the collection of a perfect body of agricultural statistics in this country. Here is a witness, who, standing on the vantage-ground of an achieved success, through a course the most natural and congenial it would be possible, *à priori*, to conceive for the accomplishment of the purpose, asserts that the adoption of a compulsory system would involve a dissolution of the one existing, and would necessitate the recourse to some other, not defined nor, perhaps, easy even to himself to point out. There is no arguing with success. But even were it otherwise, there is no lack of well-considered plans to be found in the volume of evidence referred to. Those of Mr. Leone Levi, Mr. Caird, Mr. Buckland, Mr. Farnall (each rather amusingly characteristic of the professional view, so to speak, of the proposer), we should especially instance; nor must we omit a clear-sighted plan, suggested by the 'Clerk of the Atcham Union,' and stated in Mr. Doyle's Report (1854), in which the machinery of the Census is assumed, rightly, according to the view that has shaped itself to our mind, as the model to proceed upon.

* The gentlemen examined were, Mr. Hall Maxwell, Sir John Walsham, Bart., Mr. Pigott, Mr. Hawley, Mr. Farnall; Mr. Miles (the late President of the Royal Agricultural Society), Mr. Leone Levi, Mr. Caird, Mr. Torr, Mr. Peirson, Mr. Buckland, Mr. Rodwell, Mr. Sandars, Mr. Curtis, Mr. Bunter, Mr. Bowring; with Sir Robert Fergusson, M.P., and Mr. Donnelly, for Ireland.

But meantime, even as we have written, the question has been gaining ground throughout the country. Agricultural societies have discussed it; the agricultural press has been searchingly addressed to it. But its importance has received the best of involuntary testimony in the heat and controversy raised by every published estimate of the year, such as those of Mr. Caird, Mr. Morton, Mr. Baker, and many others. In a word, the subject has been ripening into one of general interest and demand, and that in the proper quarters. It is no longer a mere hole-and-corner experiment, to be attempted only by the cheapest or most ready-made anti-friction machinery. It is called for by the awakened voice and intelligence of an agricultural community that would be ill-judged of by the errors of a first and partial experiment. The farmer is not the only Englishman who is slow in adoption, and slow in change; but the question required consideration, and it has been considered; and we rejoice to have seen the venue change itself from boards of guardians to the opener court of agricultural societies and farmers' clubs. This is the soil in which in Scotland it took root and flourished, and has borne good fruit; and this is its proper soil in England too.

In bringing to a close, for the present, a mere preliminary and imperfect essay to open a subject itself as yet imperfect, but whose growing and self-correcting details will probably furnish hereafter a topic of annual notice in the Journal of the Society, we would earnestly invite any one who may have hitherto doubted the utility, or declined to take part in the task of the collection of agricultural statistics, to consider that the ungracious reluctance to aid in a cause which is the cause of all, though it may injure the accuracy of the proportions, mar the truth and symmetry of the result, yet cannot stop the progress of the undertaking. Its aim is to exchange doubt for certainty, guesswork for fact, error for truth; and in so doing to hold up a mirror that can neither flatter nor distort, exhibiting to British agriculture a sight which it has little cause to fear, in a comparative view of the station that it holds in the industry of the world.

Mr. PUSEY.

On the 7th November, on the motion of Lord Portman, seconded by Colonel Challoner and Mr. Raymond Barker, the following resolution was carried unanimously:—

That a letter be written to the family of the late Philip Pusey, Esq., expressing the gratitude of the Royal Agricultural Society of England for his services as Chairman of the Journal Committee, and their great sorrow for his early death. That it be engrossed on vellum, and signed by the President, with the seal of the Society attached.

In pursuance of the above resolution the following letter was written by the President:—

The Council of the Royal Agricultural Society of England has directed me, as the President, to assure the family of the late Ph. Pusey, Esq., that the Society deeply and unfeignedly unite with them in their grief for the irreparable loss which they have sustained in the early and lamented death of their beloved father. In this bereavement the Council and the Society participate with the surviving and sorrowing members of Mr. Pusey's family; for while the recollection of parental affection and domestic virtue will long endear his memory to all the members of his family, his distinguished position when twice elected President of the Royal Agricultural Society of England, and his unceasing labours for seventeen years as Chairman of the Journal Committee, will long be cherished by his surviving colleagues, and be remembered with gratitude and respect by every member of this Society.

(Signed) Portman, President.

On the 12th of December the following reply, addressed to the President, was read to the Council:—

London, Dec. 12th.

My Lord,—The family of the late Mr. Pusey have requested me, as one of the executors under his will, to express to your Lordship and the Council of the Royal Agricultural Society of England their grateful sense of the sympathy shown to them in their bereavement.

They will not fail to appreciate duly such a communication from the Society, remembering how their father cherished the memory of Earl Spencer, its first President, and of others with whom he had the honour to be associated in its foundation.

Of Mr. Pusey himself, it will long be remembered that to

practical habits of business he joined deep philosophical thought, accurate scholarship, and genial appreciation of the arts and letters of modern as well as ancient times—that he applied a powerful intellect, with a keen forecast of the wants of his country, to develop the resources of British farming—and that, by a rare union of endowments, he did much to render science practical, and to win for agriculture a worthy place among the intellectual pursuits of the present day.

How much labour he underwent, what forbearance and discrimination he exercised, how considerate he was of the feelings of others, how modest in the expression of his own, may never be known except to his personal friends ; but some of the results of his unceasing exertions during many of the best years of his life are to be found in the Journal (to which the Council have referred by their resolution) ; and by that Journal at least his name will be permanently and honourably connected with the Society from the date of its commencement.

This may not be the occasion on which to speak of his exertions for the labouring poor, or of his private virtues, but I trust that I shall be pardoned for having said thus much in response to the recognition of Mr. Pusey's services by the important public body over which your Lordship presides.

I have only further to request that you will be pleased to convey to the Council the respectful acknowledgments of Mr. Pusey's friends, and that you will accept personally their sincere thanks for the kind terms in which your letter to the family is expressed.

I have the honour to be, my Lord,

Your Lordship's faithful servant,

THOMAS DYKE ACLAND, Jun.

THE RT. HON. LORD PORTMAN.

On the motion of Mr. Samuel Jonas, seconded by Mr. Fisher Hobbs, it was resolved that the foregoing letters be entered in the proceedings of the day, and be printed in the forthcoming Number of the Journal.

END OF VOL. XVI.

LONDON : PRINTED BY W. CLOWES AND SONS, STAMFORD STREET, AND CHARING CROSS.

Royal Agricultural Society of England.

1854—1855.

MEMORANDA.

COUNTRY MEETING at Carlisle in 1855, in the week commencing Monday, the 23rd of July.

GENERAL MEETING in London, on Saturday, the 14th of December, at Eleven o'clock, A.M.

GENERAL MEETING in London, on Thursday, May 22, 1856, at Twelve o'clock.

MONTHLY COUNCIL (for transaction of business), at 12 o'clock on the first Wednesday in every month, excepting January, September, and October: open only to Members of Council and Governors of the Society.

WEEKLY COUNCIL (for practical communications), at 12 o'clock on all Wednesdays in February, March, April, May, June, and July, excepting the first Wednesday in each of those months, and during adjournment: open to all Members of the Society.

ADJOURNMENTS.—The Council adjourn over Easter week, and occasionally over Passion and Whitsun weeks; from the first Wednesday in August to that in November; and from the Wednesday in the week of the December General Meeting to the first Wednesday in February.

GUANO analysed for Members at a reduced rate by Professor WAY, at 23, Holles Street, Cavendish Square, London.—(Statement of Members' Privileges of Chemical Analysis given in Journal, vol. XIII., Appendix, p. xxxiv, and may be obtained separately on application to the Secretary.)

DISEASES of Cattle, Sheep, and Pigs.—Members have the privilege of applying to the Veterinary Committee of the Society; and of sending animals to the Royal Veterinary College, on the same terms as if they were subscribers to the College.—(Statement of Members' Veterinary Privileges given in Journal, vol. XI., Appendix, pp. viii, ix; vol. XII., Appendix, p. iv; vol. XIII., Appendix, p. xxxiv; vol. XIV., Appendix, p. v.; and may be had separately on application to the Secretary.)

LOCAL CHEQUES: requested not to be forwarded for payment in London; but London Cheques, or Post-office Orders (payable to "James Hudson"), to be sent in lieu of them. Members may conveniently transmit their Subscriptions to the Society, by requesting their Country Bankers to pay (through their London Agents) the amount at the Society's Office (No. 12, Hanover Square, London), between the hours of ten and four, when official receipts will be given.

NEW MEMBERS.—1. *Nomination:* Every candidate for admission into the Society must be proposed by a Member; the proposer to specify in writing the name, rank, usual place of residence, and post-town, of the candidate, either at a Council, or by letter to the Secretary. Every such proposal will be read at the Council at which such proposal is made; or, in the case of the Candidate being proposed by a letter to the Secretary, at the first meeting of the Council next after such letter shall have been received.—2. *Election:* At the next Monthly Meeting of the Council the election will take place, when the decision of the Council will be taken by a show of hands; the majority of the Members present to elect or reject. The Secretary will inform Members of their election by a letter, in such form as the Council may from time to time direct.—Candidates residing out of the United Kingdom can only be elected as Life-Governors or Life-Members, and are required to make in one payment on election a composition for annual subscriptions.

FARMING ACCOUNTS recommended by a Committee of the Society sold to Members at a reduced rate, by Messrs. Hallifax, the Stationers to the Society, 315, Oxford Street, London.

*** Members may obtain on application to the Secretary copies of an Abstract of the Charter and Bye-Laws, of a Statement of the General Objects, &c., of the Society, and of other printed papers connected with special departments of the Society's business.

Royal Agricultural Society of England.

GENERAL MEETING,

12, Hanover Square, Tuesday, May 22, 1855.

REPORT OF THE COUNCIL.

Since the last Half-yearly Meeting in December, the Society has lost, by death and otherwise, 227 of its members, and has gained by election 132 new members. The Council, on the recommendation of the Finance Committee, have also removed from the list of the Society the names of 285 members who have made no payment during the last seven years. They have unanimously elected Dr. Edward Hartstein, Professor of Agriculture in the Royal Academy of Poppelsdorf, an honorary member of the Society. The Society accordingly now consists of

89 Life Governors,
141 Annual Governors,
795 Life Members,
3838 Annual Members, and
19 Honorary Members,

making a total of 4882 names on its list at the present date.

The funded property of the Society stands at 9264*l.* 8*s.* 11*d.* in the Stock which has now become the New Three per Cents.; the current cash-balance in the hands of the bankers being 3225*l.*, which includes 1400*l.* as a contribution from the authorities of Carlisle towards the expenses of the country meeting of this year.

Since the date, in November last, when the Council ordered the sale of 1500*l.* from the invested capital, the following payments have been received :—

Arrears of subscription	£1,677
Current subscriptions	1,847
Life-compositions	389
	£3,913

while every claim against the Society has been duly discharged.

The continued indisposition of Mr. Pusey, and the consequent suspension of his long and invaluable labours to the Society as the Chairman of the Journal Committee, have rendered some new arrangements in that department necessary. The Council have accordingly requested Mr. Thompson to act as the Chairman, and Mr. Wren Hoskyns and Mr. Dyke Acland as Vice-Chairmen, of the Journal Committee. The new number is now in progress, and will be published on the 1st of July. Prizes have been awarded to reports on the Farming of Buckinghamshire and Warwickshire, and also to essays on the causes of Fertility and Barrenness in Soils, and Lameness in Sheep and Lambs: a paper in the latter class has been disqualified, on account of its delivery not having been made by the 1st of March; and the prize in the class of Mildew in Wheat withheld, in consequence of the want of sufficient merit in the competing essays; while adjudications have still to be reported in the five remaining classes. The following subjects for the essays of next year have already been adopted :—

1. Farming of Bedfordshire.
2. On the Production of Turnips possessing good keeping qualities.
3. Spring-feed Crops: with special reference to early growth.
4. The different mechanical modes of deepening the Staple Soil, in order to give it the full benefit of atmospheric influence.
5. The Chemical results superinduced in newly-deepened soil by atmospheric action.

6. The construction and maintenance of Farm Roads: with special reference to clay lands.
7. The Roots of the Wheat Plant: the history of their growth and development.
8. Essay and Plans for the construction of Labourers' Cottages: with special reference to domestic convenience.
9. Account of the different modes of bringing Moorland into cultivation, based on practical experience; and specifying the methods pursued, the expense incurred, and the results as far as ascertained, regard being had to the subsoil, locality, and elevation.

Two distinct and important investigations are in progress by the Consulting-Chemist of the Society, namely—1. On the chemical effects of the Atmosphere on the Soil and Vegetation; 2. On the value to the Farmer of different substances sold to him for manuring purposes. Professor Way has already, in the course of this session, delivered before the members two lectures—the first, On the Atmosphere as a source of nitrogen to plants; and the second, On the chemical principles involved in the production of Butter—for which he has received the cordial thanks of the Council. He has also consented to deliver a lecture, on the 13th of June, On the use of Fish as Manure; and Professor Simonds, as the Veterinary Inspector of the Society, has expressed his willingness to elucidate before the members, at a Weekly Council in the course of next month, the Physiological Conditions affecting the quantity and quality of Milk secreted by the Cow under different circumstances of feeding and management.

The Governors of the Royal Veterinary College have made a most satisfactory report to the Council of the successful manner in which the special objects of the Society, in reference to domesticated animals, have been carried out in that establishment under the inspection of Professor Simonds.

The programme of the Country Meeting, to be held in the

city of Carlisle, in the week commencing Monday, the 23rd of July next, has just been issued, and the arrangements are nearly completed. At this Meeting, so favourably situated in reference to the south of Scotland and the north of Ireland, additional prizes are offered for reaping-machines and steam-cultivators, as well as for Scotch and Galloway cattle, Cheviot and Herdwick sheep, and for Clydesdale and other horses.

The entries for implements closed on the 1st instant; and though the number is not equal to that of either of the last two years, it has been ascertained that the covered shedding, 20 feet wide, engaged by exhibitors in that department, will extend to very nearly three-quarters of a mile in length. The entries for live-stock, which will not close till the 1st of June, are already numerous.

The Council have again to acknowledge the liberality and ready co-operation of the Railway Companies in promoting the objects of the Society in the transit of live-stock and implements to the Country Meeting. The principal Companies have already signified their consent to a renewal of their concessions of last year in favour of the exhibitors at the Carlisle Meeting.

The Council have decided to hold the Country Meeting of 1856 in the district comprising the counties of Bedford, Buckingham, Cambridge, Essex, Hertford, and Huntingdon, at Chelmsford, the county town of Essex.

They have also determined that the Country Meeting shall be held, four years hence, in the central district, which will comprise the counties of Oxford, Warwick, Northampton, and Berks; and thus, after a circuit of twenty years, the Society will return to that part of the kingdom in which, at the city of Oxford, under the most favourable circumstances, it held its first Meeting.

The Council have viewed with much interest the progress of measures adopted by the Government of France to stimulate and improve its agriculture. At the request of the French and English Foreign Departments, the Council have taken every

means to make known in this country the inducements held out and the facilities afforded to the exhibitors of the United Kingdom at the Agricultural Meeting to be held next month in Paris; and they have decided that six of their members shall form a deputation to be present on that occasion. The Council trust that this international gathering will be attended with the most favourable results to the agriculture of the two nations as well as to the cordial understanding now so happily subsisting between them.

The Council have continued to be favoured by the Earl of Clarendon with copies of successive despatches received at the Foreign Office from her Majesty's ministers and consuls abroad, reporting the result of their inquiries and researches connected with the occurrence of guano or the nitrates in tropical districts. Some of these communications have been of an important character, and have referred to discoveries of extensive deposits of those valuable manures, as well as to the occurrence of an unlimited supply of native carbonate of soda in South America. His Lordship has conveyed to the Council an assurance that whatever facilities or privileges are granted to other countries by the Governments within whose territories these newly-discovered deposits occur, will be claimed by her Majesty's Government on behalf of the agricultural and commercial communities of the United Kingdom.

By order of the Council,

JAMES HUDSON,

Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

Half-Yearly Account, ending December 30, 1854.

Receipts.

	£.	s.	d.
Balance in the hands of the Bankers, July 1, 1854	1295	6	9
Balance of Petty Cash in the hands of the Secretary, July 1, 1854	29	10	2
Dividends on Stock	164	14	5
Sale of Stock (£1500 New 3 per Cents. at $90\frac{3}{8}$ and commission)	1353	15	0
Governor's Life-Composition	50	0	0
Governors' Annual Subscriptions	100	0	0
Members' Life-Compositions	199	0	0
Members' Annual Subscriptions	1641	0	0
Receipts on account of Journal	176	4	6
Receipts on account of Gloucester Meeting	18	7	3
Receipts on account of Lincoln Meeting	2248	9	9
	£7276	7	10

(Signed) THOMAS RAYMOND BARKER,
Chairman of Finance Committee.

Payments.

	£.	s.	d.
Permanent Charges	174	5	0
Taxes and Rates	18	4	0
Establishment	437	8	7
Postage and Carriage	16	8	0
Advertisements	4	19	6
Payments on account of Journal	928	7	10
Veterinary Grant: half a year	100	0	0
Chemical Grant: half a year	150	0	0
Payments on account of Gloucester Meeting	31	4	6
Payments on account of Lincoln Meeting	4225	5	2
Sundry items of Petty Cash, amounting to	2	4	5
Balance in the hands of the Bankers, December 30, 1854	1184	4	7
Balance of Petty Cash in the hands of the Secretary, December 30, 1854	3	16	3
	£7276	7	10

Examined, audited, and found correct, this 18th day of May, 1855.

(Signed) THOMAS KNIGHT,
GEORGE I. RAYMOND BARKER,
GEORGE DYER,
Auditors on the part of the Society.

Essays and Reports.—PRIZES FOR 1856.—All Prizes of the Royal Agricultural Society of England are open to general competition. Competitors will be expected to consider and discuss the heads enumerated.

I. FARMING OF BEDFORDSHIRE.

FIFTY SOVEREIGNS will be given, by the Society, for the best Report on the Farming of Bedfordshire.

1. Physical characteristics of the county; climate, surface, rivers; geological subdivisions and peculiarities, noting differences, if any, of farm-practice traceable thereto.
2. Agricultural divisions; proportion of meadow, pasture, and arable; peat land; ordinary course of cropping on light and on heavy soils; treatment of clays; drainage; irrigation; dairy practice; farms of particular note; markets; population.
3. Notice of former agricultural reports of the county; improvements since Bachelor's survey; further changes needed.

II. KEEPING QUALITIES OF TURNIPS.

TWENTY SOVEREIGNS will be given for the best Essay on the production of Turnips possessing good keeping qualities, and their preservation to a late period of the season.

1. Kinds best adapted for storing.
2. Keeping qualities; how far affected by nature of soil; by early or late sowing; by heavy dressings; by special kinds of tillage; by the character of the season.
3. Drawing, and storing.

III. SPRING-FEED CROPS.

TEN SOVEREIGNS will be given for the best Essay on Spring-feed Crops, with special reference to early growth.

IV. DEEPENING THE STAPLE SOIL.

Twenty Sovereigns will be given for the best Essay on the different mechanical modes of Deepening the Staple soil, in order to give it the full benefit of atmospheric influence.

1. Deep-ploughing, comparative effect of, at springtime and autumn.
2. Subsoiling, especially upon lands recently drained.
3. Trench-ploughing; forking, digging, &c.
4. Is pulverization sufficient without inversion of the soil?

V. ATMOSPHERIC ACTION ON NEWLY-DEEPENED SOIL.

Forty Sovereigns will be given for the best Essay on the Chemical Results superinduced in Newly-deepened Soil by Atmospheric Action.

1. Effect of frost and alternations of temperature.
2. Of rain, and of its passage through newly-exposed virgin soil.
3. Results produced by exposure to light.
4. Comparative absorptive power of old and newly-raised soils.
5. Changes in the oxides of iron, &c.

VI. FARM-ROADS.

Ten Sovereigns will be given for the best Essay on the Construction and Maintenance of Farm-roads, with special reference to clay lands.

VII. ROOTS OF THE WHEAT-PLANT.

Twenty Sovereigns will be given for the best Essay on the Roots of the Wheat-plant, describing their growth and development.

1. Characteristics of roots of Autumn and Spring sown wheats.
2. Acclimatization.
3. Development, to what extent affected by top dressings at various periods of growth.
4. Lifting action of frost, commonly called "throwing out."

VIII. CONSTRUCTION OF LABOURERS' COTTAGES.

Twenty Sovereigns will be given for the best Essay and Plans for the Construction of Labourers' Cottages, with special reference to domestic convenience.

1. Arrangement of rooms and internal fittings.
2. Economy of warmth.
3. Ventilation.
4. Drainage.

IX. BRINGING MOORLAND INTO CULTIVATION.

Twenty Sovereigns will be given for the best Account of the different modes of bringing Moorland into Cultivation, based on practical experience, and specifying the methods pursued, the expense per acre, and the results ascertained; regard being had to subsoil, locality, and elevation.

1. Drainage.
2. Fencing.
3. Cultivation.
4. Course of cropping.

X. ANY OTHER AGRICULTURAL SUBJECT.

Ten Sovereigns will be given for the best Essay or Report on any other Agricultural subject.

The Reports or Essays competing for these Prizes must be sent to the Secretary of the Society, at 12, Hanover Square, London, on or before March 1, 1856. Contributors of Papers are requested to retain Copies of their Communications, as the Society cannot be responsible for their return.

Rules, &c.

RULES OF COMPETITION FOR PRIZE ESSAYS.

1. All information contained in Prize Essays shall be founded on experience or observation, and not on simple reference to books or other sources. Competitors are requested to use foolscap or large letter paper, and not to write on both sides of the leaf.

2. Drawings, specimens, or models, drawn or constructed to a stated scale, shall accompany writings requiring them.

3. All competitors shall enclose their names and addresses in a sealed cover, on which only their motto, the subject of their Essay, and the number of that subject in the Prize List of the Society, shall be written.*

4. The President or Chairman of the Council for the time being shall open the cover on which the motto designating the Essay to which the Prize has been awarded is written, and shall declare the name of the author.

5. The Chairman of the Journal Committee shall alone be empowered to open the motto-paper of any Essay not obtaining the Prize, that he may think likely to be useful for the Society's objects; with a view of consulting the writer confidentially as to his willingness to place such Essay at the disposal of the Journal Committee.

6. The copyright of all Essays gaining Prizes shall belong to the Society, who shall accordingly have the power to publish the whole or any part of such Essays; and the other Essays will be returned on the application of the writers; but the Society do not make themselves responsible for their loss.

7. The Society are not bound to award a prize unless they consider one of the Essays deserving of it.

8. In all reports of experiments the expenses shall be accurately detailed.

9. The imperial weights and measures only are those by which calculations are to be made.

10. No prize shall be given for any Essay which has been already in print.

11. Prizes may be taken in money or plate, at the option of the successful candidate.

12. All Essays must be addressed to the Secretary, at the house of the Society.

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* Competitors are requested to write their motto on the enclosed paper on which their names are written, as well as on the outside of the envelope.

Consulting-Chemist.

Professor Way's Address is now 15, Welbeck Street, Cavendish Square, London.

Royal Agricultural Society of England.

1855—1856.

President.

LORD PORTMAN.

Trustees.

Acland, Sir Thomas Dyke, Bart., M.P.
Berners, Lord
Braybrooke, Lord
Challoner, Colonel
Graham, Rt. Hon. Sir Jas., Bart., M.P.
Neeld, Joseph, M.P.
Portman, Lord
Richmond, Duke of
Rutland, Duke of
Shelley, Sir John Villiers, Bart., M.P.
Spencer, Earl
Sutherland, Duke of

Vice-Presidents.

Ashburton, Lord
Barker, Thomas Raymond
Chichester, Earl of
Downshire, Marquis of
Egmont, Earl of
Exeter, Marquis of
Fitzwilliam, Earl
Hardwicke, Earl of
Hill, Viscount
Johnstone, Sir John V. B., Bart., M.P.
Miles, William, M.P.
Yarborough, Earl of

Other Members of Council.

Acland, Thomas Dyke
Barnett, Charles
Barrow, William Hodgson, M.P.
Barthropp, Nathaniel George
Bramston, Thomas William, M.P.
Brandreth, Humphrey
Bridport, Lord
Cavendish, William George
Darnley, Earl of
Denison, John Evelyn, M.P.
Druce, Samuel
Essex, Earl of
Feversham, Lord
Foley, John Hodgetts H., M.P.
Garrett, Richard
Gibbs, B. T. Brandreth
Hamond, Anthony
Hobbs, William Fisher
Hoskyns, Chandos Wren
Hudson, John
Jonas, Samuel
Kinder, John
Lawes, John Bennet
Lawrence, Charles
Lemon, Sir Charles, Bart., M.P.
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March, Earl of, M.P.
Melville, Hon. Alexander Leslie
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Morgan, Sir Charles Gould, Bart.
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Paine, John Mainwaring
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Ridley, Sir Matthew White, Bart.
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Simpson, William
Slaney, Robert Aglionby
Smith, Robert
Southampton, Lord
Thompson, Henry Stephen
Towneley, Lieut.-Colonel Charles
Turner, Charles Hampden
Turner, George
Vyner, Captain Henry
Webb, Jonas
Western, Thomas Burch
Wilson, Henry
Woodward, Francis
Wynn, Sir Watkin Williams, Bart., M.P.

Secretary.

JAMES HUDSON, 12, *Hanover Square, London.*

Consulting-Chemist—JOHN THOMAS WAY, 15, Welbeck Street, Cavendish Square.
Veterinary-Inspector—JAMES BEART SIMONDS, Royal Veterinary College.
Consulting Engineer—JAMES EASTON, or C. E. AMOS, The Grove, Southwark.
Seedsmen—THOMAS GIBBS and Co., Corner of Halfmoon Street, Piccadilly.
Publisher—JOHN MURRAY, 50, Albemarle Street.
Bankers—A. M., C., A. R., H., R., and E. A. DRUMMOND, Charing Cross.

MEMORANDA.

GENERAL MEETING in London, on Thursday, May 22, 1856, at Twelve o'clock.

COUNTRY MEETING at Chelmsford in 1856.

GENERAL MEETING in London, on the Saturday of the Smithfield Club-Show week, at Eleven o'clock, A.M.

MONTHLY COUNCIL (for transaction of business), at 12 o'clock on the first Wednesday in every month, excepting January, September, and October: open only to Members of Council and Governors of the Society.

WEEKLY COUNCIL (for practical communications), at 12 o'clock on all Wednesdays in February, March, April, May, June, and July, excepting the first Wednesday in each of those months, and during adjournment: open to all Members of the Society, who are particularly invited by the Council to avail themselves of this privilege.

ADJOURNMENTS.—The Council adjourn over Easter week, and occasionally over Passion and Whitsun weeks; from the first Wednesday in August to that in November; and from the first Wednesday in December to the first Wednesday in February.

GUANO analysed for Members at a reduced rate by Professor WAY, at 15, Welbeck Street, Cavendish Square, London.—(Statement of Members' Privileges of Chemical Analysis given in Journal, vol. XIII., Appendix, p. xxxiv, and may be obtained separately on application to the Secretary.)

DISEASES of Cattle, Sheep, and Pigs.—Members have the privilege of applying to the Veterinary Committee of the Society; and of sending animals to the Royal Veterinary College, on the same terms as if they were subscribers to the College.—(Statement of Members' Veterinary Privileges given in Journal, vol. XI., Appendix, pp. viii, ix; vol. XII., Appendix, p. iv; vol. XIII., Appendix, p. xxxiv; vol. XIV., Appendix, p. v.; and may be had separately on application to the Secretary.)

LOCAL CHEQUES: requested not to be forwarded for payment in London; but London Cheques, or Post-office Orders (payable to "James Hudson"), to be sent in lieu of them. Members may conveniently transmit their Subscriptions to the Society, by requesting their Country Bankers to pay (through their London Agents) the amount at the Society's Office (No. 12, Hanover Square, London), between the hours of ten and four, when official receipts, signed by the Secretary, will be given for such payments.

NEW MEMBERS.—1. *Nomination:* Every candidate for admission into the Society must be proposed by a Member; the proposer to specify in writing the name, rank, usual place of residence, and post-town, of the candidate, either at a Council, or by letter to the Secretary. Every such proposal will be read at the Council at which such proposal is made; or, in the case of the Candidate being proposed by a letter to the Secretary, at the first meeting of the Council next after such letter shall have been received.—2. *Election:* At the next Monthly Meeting of the Council the election will take place, when the decision of the Council will be taken by a show of hands; the majority of the Members present to elect or reject. The Secretary will inform Members of their election by a letter, in such form as the Council may from time to time direct.—Candidates residing out of the United Kingdom can only be elected as Life-Governors or Life-Members of the Society, and are in each case required to make in one payment on election a composition in lieu of annual subscriptions.

FARMING ACCOUNTS recommended by a Committee of the Society sold to Members at a reduced rate, by Messrs. Hallifax, the Stationers to the Society, 315, Oxford Street, London.

** Members may obtain on application to the Secretary copies of an Abstract of the Charter and Bye-Laws, of a Statement of the General Objects, &c., of the Society, and of other printed papers connected with special departments of the Society's business.

Royal Agricultural Society of England.

GENERAL MEETING,

12, Hanover Square, Saturday, Dec. 15, 1855.

REPORT OF THE COUNCIL.

The Society, during the past half-year, has lost 40 of its Members by death; and gained, during the same period, 116 new Members by election. Its list now contains—

90 Life Governors,
140 Annual Governors,
815 Life Members,
3895 Annual Members, and
18 Honorary Members.

The Council have elected Lord Berners to fill the vacancy in the number of Trustees, occasioned by the lamented decease of Mr. Pusey; and the Earl of Essex to supply the vacancy in the General Members of Council, created by the transfer of Lord Berners's name to the class of Trustees.

The Society at large will have deeply participated with the Council, in their sense of the great loss they have sustained, in the removal of Mr. Pusey from the sphere of his invaluable labours; and from the direction of that Journal which has so long formed a strong bond of union among its members. The Council have already expressed, through their President, Lord Portman, their condolence with the family of Mr. Pusey on their irreparable loss, and their grateful remembrance of his devoted services to the Society.

The Carlisle Meeting has been one of the most successful of the efforts of the Society to promote and extend to remote districts the practical advantages arising from the trial of Implements and the exhibition of Live Stock. The lateness of the season preventing efficient trials being made of the Reaping Machines at Carlisle, they were postponed until the end of August, when they took place at Abbot's Leigh, in Somersetshire, on a farm of Mr. Miles, M.P., the President of the Society, who placed for that purpose the whole of his crops, horses, and men, at the service of the Society, and most hospitably received at Leigh Court those who officially represented the Society on that occasion.

The Council have already agreed to the Live Stock Prize-Sheet for the Country Meeting to be held next year at Chelmsford; containing, in addition to the usual prizes, classes for Foreign Cattle and Sheep, and a distinct division for Dray Horses: the arrangement of the Prizes for Farm Poultry and for Agricultural Implements and Machinery being postponed until February.

Mr. Miles, M.P., having in June last, as the President of the Society at that time, headed a Deputation of the Society to the French Agricultural Meeting at Paris, agreeably with an express invitation of the Imperial Government, has reported to the Council that the results of that mission were successful in every point of view.

The Earl of Clarendon has continued to transmit to the Society the successive returns furnished by H. M.'s Consuls residing in various tropical districts where guano, nitrates, and other manuring deposits are thought likely to be discovered. The Council have again expressed to Lord Clarendon their deep sense of his Lordship's kindness in thus continuing so effectively to promote the objects of the Society.

A claim having at length been made in form for the Society's £1000 Prize for a substitute for Guano, the Special Committee on that subject have taken it into their careful consideration;

and, on their report, the Council have resolved that the substitute proposed is not entitled to the Prize.

Since the last General Meeting Professor Simonds has delivered a lecture on the Physiology of Milk-Secretion, and Professor Way a lecture on the Value of Fish as Manure. Professor Way is also actively engaged, as the Consulting-Chemist of the Society, in prosecuting important researches under the direction of the Chemical Committee.

The Council, in conclusion, have every reason to congratulate the Members on the high position which the Society continues to maintain, and on the success with which its operations for promoting improvement in every branch of husbandry continue to be attended. They feel the responsibility which so great a power as the Society now possesses places in their hands, and entertain an anxious desire accordingly to render its operations sound and practical, at the same time that they are progressive. They confidently anticipate, from the union of practice with science, not only still further immediate results in the improvement of practical details, but the eventual discovery of those general principles, and their just application, without which Agriculture cannot be expected to attain the rank of a scientific pursuit, but must remain, with its full resources undeveloped and its powers restricted, a mere mechanical art, hedged in by routine, guided by guesswork, and capable only of slow and doubtful extension.

By order of the Council,

JAMES HUDSON,

Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

Half-Yearly Account, ending June 30, 1855.

Receipts.

	£.	s.	d.
Balance in the hands of the Bankers, Jan. 1, 1855	1184	4	7
Balance in the hands of the Secretary, Jan. 1, 1855	3	16	3
Dividends on Stock	130	17	3
Governor's Life-Composition	50	0	0
Governors' Annual Subscriptions, received during the half-year	441	5	0
Members' Life-Compositions	310	0	0
Members' Annual Subscriptions, received during the half-year	1886	4	0
Receipts on account of Journal	173	19	3
Receipts (in London) on account of Country Meeting during the half-year:—			
On account of Carlisle	1400	0	0
	£5580	6	4

(Signed) THOMAS RAYMOND BARKER, *Chairman*, C. B. CHALLONER, WILLIAM FISHER HOBBS, } *Finance Committee.*

Payments.

	£.	s.	d.
Permanent Charges	166	5	0
Taxes and Rates	14	18	0
Establishment	862	5	7
Postage and Carriage	25	1	1
Advertisements	9	13	3
Payments on account of Journal	623	16	10
Prizes for Essays and Reports	160	0	0
Veterinary Grant: half a year	100	0	0
Veterinary Investigations	91	7	0
Chemical Grant: half a year	150	0	0
Chemical Investigations	100	0	0
Payments (in London) on account of Country Meetings during the half-year:—			
On account of Lincoln	30	0	0
On account of Carlisle	540	2	4
Secretary's Expenses on Paris Deputation Account	14	6	0
Sundry items of Petty Cash, during the half-year	8	0	11
Balance in the hands of the Bankers, June 30, 1855	2668	12	0
Balance in the hands of the Secretary, June 30, 1855	15	18	4
	£5580	6	4

Examined, audited, and found correct, this 14th day of December, 1855.

(Signed) THOMAS KNIGHT, GEORGE I. RAYMOND BARKER, GEORGE DYER, } *Auditors on the part of the Society.*

COUNTRY-MEETING ACCOUNT: CARLISLE, 1855.

RECEIPTS.

	£.	s.	d.
Subscription from Carlisle	1400	0	0
Prizes offered by the Mayor of Carlisle	70	0	0
Prizes offered by the Local Committee at Carlisle	155	0	0
Prizes offered by Mr. Head Head of Carlisle	100	0	0
Non-Members' Fees for the entry of Live Stock	214	0	0
Non-Members' Fees for the entry of Implements	22	0	0
Implement-Exhibitors' payment, at half-price, for shedding required	183	10	1
Admissions to Show and Trial Yards	3260	3	10
Sale of Catalogues of Implements and Stock	425	6	1
Sale of Straw	1	0	0
Sale of Wheat and Barley, in grain and flour	119	6	0
Sale of Linseed, Beans, Barley-meal, Oil-cake, and Potatoes	4	3	6
Sale of Coals and Coke	0	9	6
Sale of Sacks	1	11	0
Fines for the non-exhibition of Live Stock*	9	0	0
Fines for the non-exhibition of Implements*	5	14	9
Sale of Pavilion-Dinner Tickets	373	0	0
Sale of Council Badges	2	5	0
Interest allowed by the local Bankers at Carlisle	7	9	4
Excess of Payments over Receipts, on account of the Carlisle Meeting, chargeable on the General Funds of the Society	860	8	6
	£7214	7	7

(Signed) THOMAS RAYMOND BARKER,
Chairman of Finance.

PAYMENTS.

	£.	s.	d.
Show and Trial Yard Works, Poultry-Coops, Hurdles, Entrance-Turnstiles	2243	4	4
Yardmen, Fieldmen, Clerks, Money-takers, Door-keepers, Catalogue-sellers	294	18	6
Judges of the Show	450	0	0
Judges' Refreshments	61	18	3
Veterinary-Inspector and Assistant	26	0	0
Consulting-Engineers' Account †	267	12	6
Metropolitan Police	105	6	6
Clover, Vetches, and Grass	93	10	0
Hay and Straw	86	0	4
Wheat and Barley	204	0	0
Horses, Men, Carts, Waggons; Hire of Steam-Engines; Carriage of Steam-Boiler	97	7	0
Horse and Cab Hire	7	14	0
Linseed, Beans, Barley-meal, Oil-cake, Mangold-Wurzel, Potatoes, Soda, &c.	14	17	3
Coals, Cinders, Clay, and Lime	18	19	3
Bags, Sacks, Baskets, Cordage, Chains, Bolts, and Nuts	4	5	9
Stationery and Tin-tickets	14	8	1
Advertisements	41	2	0
Postage and Carriage	58	5	2
Programmes of the Meeting	12	7	6
Prize-sheets, Certificates, Labels, Admission-Orders, Circulars, Railway-Papers, &c.	195	4	0
Live-stock and Implement Catalogues	248	2	0
Live-stock and Implement Award-sheets	20	15	0
Prizes of the Society, awarded and paid ‡	1525	4	0
Prizes of the Mayor of Carlisle, awarded and paid	70	0	0
Prizes of the Local Committee at Carlisle, awarded and paid	155	0	0
Prizes of Mr. Head Head of Carlisle, awarded and paid	100	0	0
Pavilion-Building Contract (and extra-work, 7*l.* 10*s.*)	347	10	0
Pavilion-Dinner Contract	400	0	0
Pavilion Tickets, Toast Lists, and Toastmaster	4	18	0
Badges for Council, Stewards, and Judges	8	10	2
Official Staff: Travelling Expenses, Board, and Lodging	19	16	6
Extra Clerk and Messenger	6	6	0
Surveying Crops	1	11	6
Commission charged by the local Bankers at Carlisle	9	14	0
	£7214	7	7

* *Fines* remaining unpaid: Live-Stock, 32*l.* 10*s.*; Implements, 23*l.* 0*s.* 3*d.* † *Testing apparatus.*—The amount expended in the purchase of new dynamometrical apparatus of a permanent character is not charged to the account of the year's meeting at Carlisle. ‡ *Prizes* remaining unpaid: Eight, amounting to 70*l.*, withheld until the animal in each case shall have been certified to have produced a live calf before the 31st of January, 1856.

SHOW AT CARLISLE: JULY, 1855.

STEWARDS OF THE YARD.

Stewards of Cattle.

William Simpson,
Francis Woodward,
Sir Stafford Northcote, Bt., M.P.

Stewards of Implements.

William Fisher Hobbs,
William George Cavendish,
Chandos Wren Hoskyns.

Steward of Farm-Poultry.

The Hon. and Rev. Stephen Willoughby Lawley.

Honorary Director of the Show.

B. T. Brandreth Gibbs.

Steward-Elect of Implements.

Sir Archibald Macdonald, Bt.

JUDGES.

Short-Horns.

Thomas Parkinson,
Captain Thomas Ball,
Richard Dudding.

Herefords, Devons, and Other Breeds.

Henry Chamberlain,
Edward Lane Franklin,
Henry Trethewy.

Scotch Cattle.

Patrick Graham Barns,
Robert Hector,
William Macculloch.

Horses.

John Harrison Bland,
Thomas Hunt.

William Greaves,
William Walker.

Leicester Sheep.

Robert Boughen Aylmer,
William Torr,
John Wright.

Southdown (or other Short-woolled) Sheep.

George Brown,
Henry Philip Hart,
John Waters.

Long-woolled Sheep (not Leicesters), and Improved-Lincoln Sheep.

Hugh Aylmer,
Thomas Boot Colton,
Nath. Chamberlain Stone.

Mountain Sheep.

William Dodd,
Robert Donkin,
Andrew Douglas.

Pigs.

Henry Eddison,
Philip Halse,
William Hesseltine.

Farm-Poultry.

George James Andrews,
William Trotter.

Implements.

William Blackett,
Henry Berney Caldwell,
John Clarke,
Lawrence Furniss,
John Viret Gooch,
Thomas William Granger,
Thomas Huskinson,
James Hall Nalder,
William Owen,
Clare Sewell Read,
John Jephson Rowley,
Thomas Scott.

Veterinary-Inspector.

Professor Simonds,
Royal Veterinary College.

Consulting-Engineer.

Charles Edwards Amos
(Firm of Easton and Amos).

AWARD OF PRIZES.

CATTLE: *Short-Horns.*

RICHARD BOOTH, of Warlaby, Northallerton, Yorkshire: the Prize of THIRTY SOVEREIGNS, for his 3 years and 9 months-old Short-horned White Bull "Windsor;" bred by himself.

LORD FEVERSHAM, of Duncombe Park, Yorkshire: the Prize of FIFTEEN SOVEREIGNS, for his 3 years and 2 months-old Short-horned White Bull "Highland Duke;" bred by himself.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park, Lancashire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 1 year and 11 months-old Short-horned Roan Bull "Master Butterfly;" bred by himself.

FRANCIS HAWKESWORTH FAWKES, of Farnley Hall, Otley, Yorkshire: the Prize of FIFTEEN SOVEREIGNS, for his 1 year and 5 months-old Short-horned Roan Bull "John-o'-Groat;" bred by himself.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park: the Prize of FIVE SOVEREIGNS, for his 9 months-old Short-horned White Bull-Calf "Musician;" bred by himself.

RICHARD BOOTH, of Warlaby: the Prize of TWENTY SOVEREIGNS, for his 4 years and 4 months-old Short-horned Roan Cow "Bridesmaid," In-milk and In-calf; bred by himself.

JAMES DOUGLAS, of Athelstaneford Farm, Drem, Haddingtonshire: the Prize of TEN SOVEREIGNS, for his 3 years and 2 months-old Short-horned Red Cow "Rose of Summer," In-milk and In-calf; bred by himself.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park; the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 9 months-old Short-horned Roan Heifer "Roan Duchess 2nd," In-milk and In-calf; bred by himself.

RICHARD BOOTH, of Warlaby: the Prize of TEN SOVEREIGNS, for his 2 years and 3 months-old Short-horned White Heifer "Bride-Elect," In-calf; bred by himself.

JOHN HALL, of Kiveton Park, Worksop, Nottinghamshire: the Prize of TEN SOVEREIGNS, for his 1 year and 9 months-old Short-horned Roan Heifer "Canney;" bred by himself.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park: the Prize of FIVE SOVEREIGNS, for his 1 year and 3 months-old Short-horned White Heifer "Vestris 3rd;" bred by himself.

CATTLE: *Herefords.*

LORD BERWICK, of Cronkhill, Salop: the Prize of THIRTY SOVEREIGNS, for his 2 years 9 months and 26 days-old Hereford Red (white-faced) Bull "Attingham;" bred by himself.

EARL OF RADNOR, of Coleshill House, Berkshire: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 9 months-old Hereford Red (white-faced) Bull "Carlisle;" bred by himself.

LORD BERWICK, of Cronkhill: the Prize of TWENTY-FIVE SOVEREIGNS, for his 1 year 9 months and 16 days-old Hereford Red (white-faced) Bull (without name); bred by himself.

JOHN MONKHOUSE, of The Stow, near Hereford: the Prize of FIFTEEN SOVEREIGNS, for his 1 year and 7 months-old Hereford Red (grey-backed, white-faced) Bull "Columbus;" bred by himself.

EDWARD WILLIAMS, of Lowess Court, near Hay: the Prize of FIVE SOVEREIGNS, for his 9 months and 1 week-old Hereford Brown Bull-Calf "Radnor;" bred by himself.

JOHN MONKHOUSE, of The Stow: the Prize of TWENTY SOVEREIGNS, for his 10 years and 7 months old Hereford Red (white-faced) Cow "Winifred," In-milk and In-calf; bred by James Rea, of Monaughty, near Knighton.

PHILIP TURNER, of The Leen, near Pembridge, Leominster: the Prize of TEN SOVEREIGNS, for his 3 years and 9 months-old Hereford Red (white-faced) Cow "Novice," In-milk and In-calf; bred by himself.

JOHN WALKER, of Westfield House, Holmer, near Hereford: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 8 months-old Hereford Red (white-faced) Heifer "Lady Lincoln," In-calf; bred by himself.

WILLIAM PERRY, of Cholstrey, near Leominster: the Prize of TEN SOVEREIGNS, for his 2 years 8 months and 18 days-old Hereford Dark-red (white-faced) Heifer (without name), In-calf; bred by himself.

LORD BERWICK, of Cronkhill: the Prize of TEN SOVEREIGNS, for his 1 year and 4 months-old Hereford Red (white-faced) Heifer (without name); bred by himself.

WALTER MAYBERY, of Brecon: the Prize of FIVE SOVEREIGNS, for his 1 year 11 months and 12 days-old Hereford red-and-white Heifer "Zoe;" bred by himself.

CATTLE: *Devons.*

JAMES QUARTLY, of Molland House, South-Molton: the Prize of THIRTY SOVEREIGNS, for his 2 years and 6 months-old Devon Red Bull "Napoleon;" bred by himself.

JAMES QUARTLY, of Molland House: the Prize of FIFTEEN SOVEREIGNS, for his 3 years and 7 months-old Devon Red Bull "Duke of Wellington;" bred by himself.

GEORGE TURNER, of Barton, near Exeter: the Prize of TWENTY-FIVE SOVEREIGNS, for his 1 year and 4 months-old Red Bull "Omar Pasha;" bred by himself.

WALTER FARTHING, of Stowey Court, Bridgewater: the Prize of FIFTEEN SOVEREIGNS, for his 1 year 6 months and 1 week-old Devon Red Bull "Lord Quantock;" bred by the late Samuel Farthing, of Stowey Court.

GEORGE TURNER, of Barton, near Exeter: the Prize of FIVE SOVEREIGNS, for his 8 months-old Devon Red Bull-Calf "Zouave;" bred by himself.

GEORGE TURNER, of Barton: the Prize of TWENTY SOVEREIGNS, for his 6 years and 4 months-old Devon Red Cow "Lady," In-milk and In-calf; bred by himself.

GEORGE TURNER, of Barton: the Prize of TEN SOVEREIGNS, for his 5 years and 6 months-old Devon Red Cow "Hawthorn," In-milk; bred by himself.

JAMES QUARTLY, of Molland House: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 6 months-old Devon Red Cow "Stately," In-calf; bred by himself.

GEORGE TURNER, of Barton: the Prize of TEN SOVEREIGNS, for his 2 years and 3 months-old Devon Red Heifer "Titania," In-calf; bred by himself.

JAMES QUARTLY, of Molland House: the Prize of TEN SOVEREIGNS, for his 1 year and 6 months-old Devon Red Heifer "Nonpareil;" bred by himself.

JAMES QUARTLY, of Molland House: the Prize of FIVE SOVEREIGNS, for his 1 year and 6 months-old Devon Red Heifer "Moss Rose;" bred by himself.

CATTLE: *Ayrshires.*

JOHN STEWART, of Strathaven, Lanarkshire: the Prize of TEN SOVEREIGNS, for his 5 years and 3 months-old Ayrshire Brown (brindle and white) Bull "Walter;" bred by Robert Mackean, of Lumloch, Lanarkshire.

JOHN STEWART, of Strathaven: the Prize of TEN SOVEREIGNS, for his 1 year and 4 months-old Ayrshire Brown-and-white Bull (without name); bred by William Stewart, of Lochridge, Ayrshire.

WILLIAM MUIR, of Hardington Mains, Wiston, near Biggor, Lanarkshire: the Prize of TEN SOVEREIGNS, for his 4 years and 3 months-old Ayrshire Brown-and-white Cow "Lady Scott;" bred by James Scott, of Cambuslang, near Glasgow.

JOHN STEWART, of Strathaven: the Prize of FIVE SOVEREIGNS, for his 2 years and 4 months-old Ayrshire Brown-and-white Heifer (without name); bred by J. Pollock, of Broomer, Ayrshire.

CATTLE: *Angus and other Polled Breeds.*

WILLIAM MACCOMBIE, of Tillyfour, near Aberdeen: the Prize of TEN SOVEREIGNS, for his 3 years and 4 months-old Black Bull "Hanton," of the Angus breed; bred by Alexander Bowie, of Mains-of-Kelly, near Arbroath.

[No entry for the Prize of TEN SOVEREIGNS offered for the best yearling Bull in this division.]

WILLIAM MACCOMBIE, of Tillyfour: the Prize of TEN SOVEREIGNS, for his 5 years and 4 months-old Black Cow (without name), of the Angus breed; bred by himself.

WILLIAM MACCOMBIE, of Tillyfour: the Prize of FIVE SOVEREIGNS, for his 2 years and 6 months-old Black Heifer (without name), of the Angus breed; bred by himself.

CATTLE: *Highland and other Horned Breeds.*

[No competition for the Prize of TEN SOVEREIGNS offered for the best Bull, of any age, in this division.]

NEILL MALCOLM, of Poltalloch, Callton Mor, near Lochgilphead: the Prize of TEN SOVEREIGNS, for his 1 year and 3 months-old Black Bull "Young Glenlyon," of the West-Highland breed; bred by himself.

NEILL MALCOLM, of Poltalloch: the Prize of TEN SOVEREIGNS, for his 6 years and 2 months-old Black Cow "Duebeg," of the West-Highland breed; bred by himself.

[No entry for the Prize of FIVE SOVEREIGNS offered for the best In-calf Heifer in this division.]

HORSES.

EDWARD and MATTHEW REED, of Beamish Burn, near Chester-le-Street, Durham: the Prize of THIRTY SOVEREIGNS, for their 6 years-old Bay Cart-Stallion "Nonpareil;" bred by William Wright, of Stonesby, Leicestershire.

SAMUEL and ROBERT SPENCER, of Flecknoe, near Daventry, Northamptonshire: the Prize of TWENTY SOVEREIGNS, for their 5 years and 2 months-old Grey Dray-Stallion "George the Second;" bred by J. Dodd, of Byfield, Northamptonshire.

ROBERT SMITH, of Ladyland, near Dumfries: the Prize of TWENTY SOVEREIGNS, for his 2 years-old Dark-Bay Stallion (without name) for agricultural purposes; bred by himself.

HENRY BAILEY, of Walgaston Farm, near Berkeley, Gloucestershire: the Prize of TEN SOVEREIGNS, for his 2 years-old Black Leicestershire Stallion "Koh-i-noor," for agricultural purposes; bred by himself.

SAMUEL and ROBERT SPENCER, of Flecknoe: the Prize of FIFTEEN SOVEREIGNS, for their 1 year and 2 months-old Brown-Roan Agricultural Stallion (without name); bred by Robert Cowley, of Kilsby, Northamptonshire.

DAVID BIRD, of Catterlen Hall, Newton, near Penrith, Cumberland: the Prize of TWENTY SOVEREIGNS, for his 12 years-old Black Mare "Snip," and

Foal for agricultural purposes: the Mare bred by the late Stephen Stagg, of Spire House, Penrith; the sire of the Foal, "Newminister."

ROBERT MURRAY, of Park Gate Hall, Wigton, Cumberland: the Prize of TEN SOVEREIGNS, for his 12 years-old Grey Agricultural Mare "Diamond," and Foal: the Mare bred by Robert Murray, of Farnrigg Moor, near Wigton; the sire of the Foal, "Glancer."

EDWARD HOLLAND, M.P., of Dumbleton Hall, near Evesham, Worcestershire: the Prize of FIFTEEN SOVEREIGNS, for his 2 years-old Red-roan Cart-Filly (without name); bred by himself.

EDWARD HOLLAND, M.P., of Dumbleton Hall: the Prize of TEN SOVEREIGNS, for his 2 years-old Iron-grey Cart-Filly (without name); bred by himself.

CHARLES PHILLIPS, of Cracop, near Brampton, Cumberland: the Prize of TWENTY SOVEREIGNS, for his 7 years and 1 month-old Clydesdale Grey Stallion "Merry Tom;" bred by himself.

JAMES NEWBIGGING, of Redhall, Kirkpatrick-Fleming, near Ecclefechan, Dumfriesshire: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 5 weeks-old Clydesdale Dark-brown Stallion "Zanthus;" bred by himself.

JAMES DOUGLAS, of Athelstaneford Farm, near Drem, Haddingtonshire: the Prize of TEN SOVEREIGNS, for his 5 years and 2 months-old Clydesdale Brown Mare "Data," and Foal; the Mare bred by J. Laurie, of Farnieflat; (the sire of the foal not stated.)

JAMES PATERSON, of Terrona, near Langholm, Dumfriesshire: the Prize of FIVE SOVEREIGNS, for his 2 years-old Clydesdale Brown Filly "Damsel;" bred by Richard Armstrong, of King-Water, near Brampton.

SHEEP: *Leicesters.*

WILLIAM SANDAY, of Holme-Pierrepoint, near Nottingham: the Prize of TWENTY-FIVE SOVEREIGNS, for his 17 months-old Leicester Ram; bred by himself.

THOMAS EDWARD PAWLETT, of Beeston, near Sandy, Bedfordshire: the Prize of FIFTEEN SOVEREIGNS, for his 15 months-old Leicester Ram; bred by himself.

WILLIAM SANDAY, of Holme-Pierrepoint: the Prize of TWENTY-FIVE SOVEREIGNS, for his 52 months-old Leicester Ram; bred by himself.

WILLIAM SANDAY, of Holme-Pierrepoint: the Prize of FIFTEEN SOVEREIGNS, for his 40 months-old Leicester-Ram; bred by himself.

WILLIAM SANDAY, of Holme-Pierrepoint: the Prize of TWENTY SOVEREIGNS, for his Pen of five 17 months-old Leicester Shearling Ewes; bred by himself.

WILLIAM SANDAY, of Holme-Pierrepoint: the Prize of TEN SOVEREIGNS, for his Pen of five 17 months-old Leicester Shearling Ewes; bred by himself.

SHEEP: *Southdowns.*

WILLIAM RIGDEN, of Hove, near Brighton: the Prize of TWENTY-FIVE SOVEREIGNS, for his 16½ months-old Southdown Shearling Ram; bred by himself.

EARL OF CHICHESTER, of Stanmer Park, near Lewes, Sussex: the Prize of FIFTEEN SOVEREIGNS, for his 16 months-old Southdown Shearling Ram, "Number Two;" bred by himself.

WILLIAM RIGDEN, of Hove: the Prize of TWENTY-FIVE SOVEREIGNS, for his 28 months-old Southdown Ram; bred by himself.

WILLIAM RIGDEN, of Hove: the Prize of FIFTEEN SOVEREIGNS, for his 40 months-old Southdown Ram; bred by himself.

HENRY LUGAR, of Hengrave, near Bury St. Edmunds: the Prize of TWENTY SOVEREIGNS, for his Pen of five 16 months-old Southdown Shearling Ewes; bred by himself.

Lord Walsingham, of Merton Hall, near Thetford, Norfolk: the Prize of Ten Sovereigns, for his Pen of five 15½ months old Southdown Shearling Ewes; bred by himself.

Sheep: *Long-wools.*

William Lane, of Broadfield Farm, Northleach, Gloucestershire: the Prize of Twenty-Five Sovereigns, for his 16 months-old Cotswold Ram; bred by himself.

William Hewer, of Northleach, Gloucestershire: the Prize of Fifteen Sovereigns, for his 16 months-old Cotswold Ram; bred by himself.

William Garne, of Aldsworth, near Northleach: the Prize of Twenty-Five Sovereigns, for his 40 months-old Cotswold Ram; bred by himself.

William Lane, of Broadfield Farm: the Prize of Fifteen Sovereigns, for his 40 months-old Cotswold Ram; bred by himself.

Thomas Beale Browne, of Hampen, near Andoversford, Gloucestershire: the Prize of Twenty Sovereigns, for his Pen of five 16 months-old Cotswold Shearling Ewes; bred by himself.

William Lane, of Broadfield Farm: the Prize of Ten Sovereigns, for his Pen of five 16 months-old Cotswold Shearling Ewes: bred by himself.

Mountain Sheep: *Herdwicks.*

George Robinson, of Orton Hall, Westmoreland: the Prize of Seven Sovereigns, for his 15 months-old Herdwick Shearling Ram; bred by himself.

John Mounsey, of Askham, near Penrith, Cumberland: the Prize of Eight Sovereigns, for his 4 years and 3 months-old Herdwick Ram; bred by Henry Howard, of Greystoke Castle.

George Robinson, of Orton Hall: the Prize of Five Sovereigns, for his Pen of five 15 months-old Herdwick Shearling Ewes; bred by himself.

Mountain Sheep: *Blackfaced.*

Hugh Shield, of High-Acton, Allendale, Northumberland: the Prize of Seven Sovereigns, for his 15 months-old Black-faced Horn Ram, "Rose of Allendale;" bred by Henry Stephenson, of Rose Hill, Weardale, Durham.

Charles Summers, of Whitfield, near Haydon Bridge, Northumberland: the Prize of Eight Sovereigns, for his 28 months-old Black-faced Ram, "Champion;" bred by Thomas Maughan, of Horsley Head, near Stanhope, Durham.

James Brydon, of Moodlaw, near Langholm, Dumfriesshire; the Prize of Five Sovereigns, for his Pen of five 1 year and 3-months old Black-faced Shearling Ewes; bred by himself.

Pigs.

Thomas Horsfall, of Burley Hall, near Otley, Yorkshire: the Prize of Ten Sovereigns, for his 2 years 10 months and 3 weeks-old Yorkshire Boar "Young Hector;" white colour with patches, and of a large breed; bred by J. Walker, of Mount Steine, Otley.

Charles Jackson, of York: the Prize of Five Sovereigns, for his 2 years and 1 month-old Yorkshire Blue and White Boar "Highland Harry," of a large breed; bred by John Hearron, of Newton-on-Derwent.

William Hatton, of Addingham, Oxley, Yorkshire: the Prize of Ten Sovereigns, for his 1 year 11 months and 3 weeks-old White Boar "Young Cupid 2nd," of a small breed; bred by John Sugden, of Keighley.

George Turner, of Barton, near Exeter: the Prize of Five Sovereigns, for his 1 year 9 months and 3 weeks-old Improved Essex Black Boar "Sambo," of a small Breed; bred by himself.

John Harrison, jun., of Heaton-Norris, Lancashire Hill, near Stockport: the Prize of Ten Sovereigns, for his 1 year 11 months and 6 days-old Breeding-Sow "Miss Carswell," white with black spots, and of a "pure" large breed; bred by J. Carswell, Park House, Butley, near Macclesfield.

Robert Harrison Watson, of Bolton Park, near Wigton, Cumberland: the Prize of Ten Sovereigns, for his 1 year 10 months and 2 weeks-old White Breeding Sow "Miss West," of a small breed; bred by himself.

William James Sadler, of Bentham, Purton, near Swindon, Wiltshire: the Prize of Ten Sovereigns, for his Pen of three 7 months and 2 days-old Breeding-Sows, black and white, and of the "pure" Berkshire large breed; bred by himself.

Robert Harrison Watson, of Bolton Park: the Prize of Ten Sovereigns, for his Pen of three 7 months 2 weeks and 5 days-old White Breeding-Sows "Faith, Hope, and Charity," of a small breed; bred by himself.

Farm Poultry: *Dorkings.*

Henry Daniel Davies, of Spring-Grove House, near Hounslow, Middlesex: the Prize of Five Sovereigns, for his 5 months and 2 weeks-old Coloured Dorking Cock and two Pullets; bred by himself.

Miss Rebecca Bell, of Woodhouselees, Canonbie, near Carlisle: the Prize of Three Sovereigns, for 5 months and 2-weeks-old Coloured Single-combed Dorking Cock and two Pullets; bred by herself.

George Atkinson Gelderd, of Aikrigg-End, near Kendal: the Prize of Two Sovereigns, for his 3 months-old Coloured Dorking Cock and two Pullets; bred by himself.

George Atkinson Gelderd, of Aikrigg-End: the Prize of One Sovereign, for his 4 months-old Coloured Dorking Cock and two Pullets; bred by himself.

Henry Daniel Davies, of Spring-Grove House: the Prize of Five Sovereigns, for his (above) 1 year-old Coloured Dorking Cock and two Hens, bred by himself.

George Atkinson Gelderd, of Aikrigg-End: the Prize of Three Sovereigns, for his 2 years and 2 months-old Coloured Dorking Cock, bred by J. J. Wilson, of Kendal; and his 3 years and 2 months-old Coloured Dorking Hens, breeder unknown.

John Hitchman, M.D., of Mickleover, near Derby: the Prize of Two Sovereigns, for his 14 months and 1 week-old Grey Dorking Cock and two Hens; bred by himself.

Thomas Ullock, of Quarry Howe, near Windermere: the Prize of One Sovereign, for his 1 year 1 month and 3 weeks-old Silver or Grey Dorking Cock, and his 1 year and 11 months-old Silver or Grey Dorking Hens; bred by himself.

Mrs. Thomas Townley Parker, of Astley Hall, near Chorley, Lancashire: the Prize of Two Sovereigns, for a 3 years and 3 months-old Dorking Cock; bred by herself.

Daniel Harrison, of Singleton Park, near Kendal: the Prize of One Sovereign, for his 1 year and 3 months-old Grey or Coloured Dorking Cock; bred by S. F. Brett, of Market Rasen.

Farm Poultry: *Spanish Fowls.*

Henry Daniel Davies, of Spring-Grove House: the Prize of Five Sovereigns, for his (above) 1 year-old Black Spanish Cock and Two Hens; breeder not stated.

William Lightfoot, of Shield Field, near Newcastle-on-Tyne: the Prize of Three Sovereigns, for his 2 years and 1 month-old White-faced Black Spanish Cock, and two Hens; bred by Captain Hornby, R.N., of Knowsley Cottage, Prescot.

Miss Rebecca Bell, of Woodhouselees: the Prize of Two Sovereigns, for her 1 year and 3 months-old Black Spanish Cock and two Hens; bred by herself.

William Lightfoot, of Shield Field: the Prize of One Sovereign, for his 1 year and 1 month-old White-faced Black Spanish Cock and two Hens; bred by himself.

James Dixon, of North Park, Horton, near Bradford, Yorkshire: the Prize of Two Sovereigns, for his White-faced Spanish Cock and two Hens; bred by John Mills, of Ovenden, near Halifax.

Farm Poultry: *Cochin-China Fowls.*

Mrs. Mary Parker, of Coalstaith, near Brampton, Cumberland: the Prize of Five Sovereigns, for her 4 months-old Cinnamon and Buff Cochin-China Cock and two Pullets; bred by J. Emery, of Kempston, Bedfordshire.

Thomas Blaylock, of Botchorley, near Carlisle: the Prize of Three Sovereigns, for his 2 months and 1 week-old Buff Cochin-China Cock and two Pullets; bred by himself.

George Dobson, of Fox-lane, Whitehaven: the Prize of Two Sovereigns, for his 2 months-old Buff Cochin-China Cock and two Pullets; bred by himself.

George Atkinson Gelderd, of Aikrigg-End: the Prize of One Sovereign, for his 16 weeks-old Buff Cochin-China Cock and two Pullets; bred by himself.

George Atkinson Gelderd, of Aikrigg-End: the Prize of Two Sovereigns, for his 2 years and 1 month-old Buff Cochin-China Cock; bred by himself.

Farm Poultry: *Brahma-Pootras.*

Henry Daniel Davies, of Spring-Grove House: the Prize of Three Sovereigns, for his (above) 1 year-old Grey Brahma-Pootra Cock and two Hens; breeder not stated.

Farm Poultry: *Game Fowls.*

Charles Richard Titterton, of Snow Hill, Birmingham: the Prize of Five Sovereigns, for his (about) 2 years-old Black-breasted Red Game Cock and two Hens; breeder unknown.

Robert Pickthall, of Mint House, Kendal: the Prize of Two Sovereigns, for his (about) 2 years and 3 months-old Black-breasted Red Game Cock and two Hens; bred by J. K. Hodgson, of Ulverston.

William Ellison, Junr., of Low Sizergh, near Milnthorp: the Prize of One Sovereign, for his 2 years and 2 months-old Duck-wing Grey Game Cock and two Hens; bred by William Wilkinson, of Brigstern, near Milnthorp.

Robert Pickthall, of Mint House: the Prize of Two Sovereigns, for his (about) 1 year and 3 months-old Black-breasted Red Game Cock; bred by J. K. Hodgson, of Ulverston.

Farm Poultry: *Hamburg Fowls.*

Daniel Harrison, of Singleton Park, near Kendal: the Prize of Two Sovereigns, for his 1 year 2 months and 2 weeks-old Golden-pencilled Hamburg Cock, bred by himself; his 1 year 2 months and 2 weeks-old Golden-pencilled Hamburg Hen, bred by Miss Walker, of Clipstone

Rectory, Northamptonshire; and his 1 year and 1 month-old Golden-pencilled Hamburg Hen, bred by the Rev. R. Pulleine, of Kirkby-Wiske Rectory, Yorkshire.

JAMES FLETCHER, of Stoneclough, near Manchester: the Prize of ONE SOVEREIGN, for his 2 years and 2 months-old Golden-pencilled Hamburg Cock, and his two 1 year and 2 months-old Golden-pencilled Hamburg Hens; bred by Joseph Whittington, Junr., of Wootton-Wawen, near Henley-in-Arden, Warwickshire.

HENRY SHARP, of Mill-lane, Bradford, Yorkshire: the Prize of TWO SOVEREIGNS, for his (above) 1 year-old Silver-pencilled Hamburg Cock and two Hens; breeder unknown.

JAMES DIXON, of North Park, Horton, near Bradford, Yorkshire: the Prize of ONE SOVEREIGN, for his 2 years-old Silver-pencilled Hamburg Cock, and his two 1 year-old Silver-pencilled Hamburg Hens; breeder not stated.

JAMES DIXON, of North Park: the Prize of TWO SOVEREIGNS, for his 2 years and 1 month-old Golden-spangled Hamburg Cock and two Hens; breeder not stated.

JAMES DIXON, of North Park: the Prize of ONE SOVEREIGN, for his 1 year-old Golden-spangled Hamburg Cock and two Hens; breeder not stated.

HENRY BELDON, of Prospect Place, Eccleshill Moor, near Bradford, Yorkshire: the Prize of TWO SOVEREIGNS, for his 2 years and 9 months-old Silver-spangled Hamburg Cock; bred by Thomas Holmes, of Baildon; and his 2 years-old Silver-spangled Hamburg Hens; bred by W. Ludlam, of Bradford.

JAMES DIXON, of North Park: the Prize of ONE SOVEREIGN, for his 2 years-old Silver-spangled Hamburg Cock, and his two 1 year-old Silver-spangled Hamburg Hens; breeder not stated.

FARM POULTRY: *Malay Fowls.*

WILLIAM LORT, of Great Heath, Tenbury, Worcestershire: the Prize of TWO SOVEREIGNS, for his 2 years and 2 months-old Malay Cock, and his two 2 years and 1 month-old Malay Hens; bred by himself.

HENRY BOLCKOW, of Marton Hall, near Middlesborough, Yorkshire: the Prize of ONE SOVEREIGN, for his (about) 18 months-old Malay Cock and two Hens; breeder unknown.

FARM POULTRY: *Poland Fowls.*

GEORGE CALEB ADKINS, of West House, Edgbaston, near Birmingham: the Prize of THREE SOVEREIGNS, for his (about) 1 year-old Silver-spangled Poland Cock and two Hens: bred by himself.

GEORGE CALEB ADKINS, of West House: the Prize of TWO SOVEREIGNS, for his (about) 3 years-old White-crested Black Poland Cock and two Hens; breeder unknown.

HENRY BOLCKOW, of Marton Hall: the Prize of ONE SOVEREIGN, for his (about) 14 months-old Silver Poland Cock and two Hens; breeder unknown.

FARM POULTRY: *Turkeys.*

[No entries were made for the three Prizes offered by the Society in this class at the Carlisle Meeting.]

FARM POULTRY: *Geese.*

HENRY AMBLER, of Watkinson Hall, near Halifax, Yorkshire: the Prize of THREE SOVEREIGNS, for his 1 year 1 month and 2 weeks-old Grey Toulouse Gander and two Geese; bred by himself.

DANIEL HARRISON, of Singleton Park, near Kendal: the Prize of TWO SOVEREIGNS, for his 1 year 2 months and 2 weeks-old Grey cross-bred Gander and two Geese; bred by Mrs. Thomas Townley Parker, of Astley Hall.

Henry Ambler, of Watkinson Hall: the Prize of One Sovereign, for his 2 years and 2 months-old White Emden Gander and two Geese; bred by himself.

Farm Poultry: *Aylesbury Ducks.*

Henry Daniel Davies, of Spring-Grove House: the Prize of Three Sovereigns, for his 2 months and 2 weeks-old White Aylesbury Drake and two Ducks; bred by himself.

Henry Daniel Davies, of Spring-Grove House: the Prize of Two Sovereigns, for his 2 months and 2 weeks-old White Aylesbury Drake and two Ducks; bred by himself.

George Atkinson Gelderd, of Aikrigg-End: the Prize of One Sovereign, for his 10 weeks-old Aylesbury Drake and two Ducks; bred by himself.

Farm Poultry: *Rouen Ducks.*

John Kersley Fowler, of Prebendal Farm, Aylesbury, Bucks: the Prize of Three Sovereigns, for his 12 weeks-old "pure" Rouen Drake and two Ducks; bred by himself.

John Kersley Fowler: the Prize of Two Sovereigns, for his 1 year and 2 months-old "pure" Rouen Drake and two Ducks; bred by J. Punchard, of Haverhill, Suffolk.

[The Prize of One Sovereign, for the third-best Rouen Drake and two Ducks, was withheld, from want of merit in the remaining poultry of this class.]

Farm Poultry: *Ducks of any other variety.*

James Dixon, of North Park, near Horton, Bradford, Yorkshire: the Prize of Two Sovereigns, for his 1 year and 1 week-old Black East-Indian Drake and two Ducks; bred by himself.

[No competition for the Prize of One Sovereign for the second-best Drake and two Ducks in this class.]

Special Prizes

OFFERED BY ROBERT FERGUSON, ESQ., MAYOR OF CARLISLE.

Richard Ferguson, of Harker, near Carlisle: the Prize of Forty Sovereigns, for his 6 years-old dark-brown, thorough-bred Stallion "Ravenhill;" bred by J. Moore, of Ravenhill, near Belfast.

Jonathan Shaw, of Acomb Hall, near York: the Prize of Thirty Sovereigns, for his 3 years-old Bay Coaching-Stallion "Canrobert;" bred by himself.

Special Prizes

OFFERED BY THE CARLISLE LOCAL COMMITTEE.

Thomas Elliott, of Hindhope, near Jedburgh, Roxburghshire: the Prize of Fifteen Sovereigns, for his 38 months-old Cheviot Ram "Sucklerigg;" bred by himself.

Thomas Charles Borthwick, of Hopsrig, near Langholme, Dumfriesshire: the Prize of Seven Sovereigns, for his 3 years and 3 months-old Cheviot Ram; bred by himself.

Thomas Elliot, of Hindhope: the Prize of Fifteen Sovereigns, for his 14 months-old Cheviot Shearling Ram; bred by himself.

Thomas Charles Borthwick, of Hopsrig: the Prize of Eight Sovereigns, for his 1 year and 3 months-old Cheviot Shearling Ram; bred by himself.

Thomas Charles Borthwick, of Hopsrig: the Prize of Ten Sovereigns, for his Pen of five 3 years and 3 months-old Cheviot Ewes; bred by himself.

THOMAS CHARLES BORTHWICK, of Hopsrig: the Prize of FIVE SOVEREIGNS, for his Pen of five 3 years and 3 months-old Cheviot Ewes; bred by himself.

THOMAS CHARLES BORTHWICK, of Hopsrig: the Prize of TEN SOVEREIGNS, for his Pen of five 1 year and 3 months-old Cheviot Shearling Ewes; bred by himself.

THOMAS ELLIOT, of Hindhope: the Prize of FIVE SOVEREIGNS, for his Pen of five 14 months-old Cheviot Shearling Ewes; bred by himself.

SIR WILFRID LAWSON, Bart., of Brayton, near Carlisle: the Prize of FIFTEEN SOVEREIGNS, for his 10 years-old Bay Mare "Madam" and her Foal; the mare bred by himself; the sire of the foal, "British Yeoman."

SIR WILFRID LAWSON, Bart.: the Prize of TEN SOVEREIGNS, for his 3 years-old Brown Harness Gelding; bred by himself.

THOMAS SWARBRECK, of Sowerby, near Thirsk, Yorkshire: the Prize of FIFTEEN SOVEREIGNS, for his 13 years-old Bay Mare "Beeswing" and her Foal, for breeding Hunters; the mare bred by William Morton, of North Kilvington, near Thirsk; sire of the foal, "Flycatcher."

ROBERT BARTON, of Barrock's Town, near Carlisle: the Prize of TEN SOVEREIGNS, for his 3 years-old Brown Hunting Gelding; bred by Thomas Story, of Cross Hill, near Carlisle.

MILES BELL, of Branstock, near Carlisle: the Prize of TEN SOVEREIGNS, for his 3 years-old Cart Filly "Jess;" bred by himself.

Mrs. ANN TINNING, of Oak Bank, near Longtown, Cumberland: the Prize of TEN SOVEREIGNS, for her 3 years-old Bay Cart Gelding "Farmer;" bred by J. Davidson, of Souterfoot, near Gretna.

WILLIAM STORDY, of Moorhouse, near Carlisle: the Prize of TEN SOVEREIGNS, for his 2 years-old Grey Cart Gelding; bred by himself.

Special Prizes

OFFERED BY GEORGE HEAD HEAD, ESQ., OF CARLISLE.

JAMES GRAHAM, of Meikle Culloch, near Dalbeattie, Kirkcudbrightshire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 3 years and 4 months-old Black Galloway Bull "Wellington;" bred by Adam Corrie, of Cairnie Hill, near Borgue.

JOHN CARRUTHERS, of Kirkhill, near Moffat, Dumfriesshire: the Prize of TEN SOVEREIGNS, for his 3 years and 3 months-old Black Galloway Bull "Ranger;" bred by William Paterson, of Twiglees, near Langholm.

JAMES BEATTIE, of Newbie House, near Annan, Dumfriesshire: the Prize of FIFTEEN SOVEREIGNS, for his 1 year and 2 months-old Black Galloway Bull "Young Moss-trooper;" bred by J. Pool, of Milnfield, near Annan.

JOHN BIRRELL, of Guards, near Gretna: the Prize of TEN SOVEREIGNS, for his 1 year and 4 months-old Black Galloway Bull "Freebooter;" bred by James Graham, of Meikle Culloch, near Castle Douglas.

JAMES BEATTIE, of Newbie House: the Prize of FIFTEEN SOVEREIGNS, for his 5 years and 3 months-old Black Galloway Cow, In-milk and In-calf; bred by James Graham, of Meikle Culloch.

JOHN GRAINGER, of Souterfield, near Abbey-Holme, Cumberland: the Prize of TEN SOVEREIGNS, for his 3 years and 10 months-old Black Galloway Cow, In-calf; bred by himself.

GEORGE RIDDICK, of Greenhill Head, near Lockerbie, Dumfriesshire: the Prize of TEN SOVEREIGNS, for his Pair of 2 years and 2 months-old Black Galloway Heifers, "Ross and Agnes," In-calf; bred by himself.

JOHN PEARSON, of Lanrig, Cumberland: the Prize of FIVE SOVEREIGNS, for his pair of 2 years and 8 months-old Black Galloway Heifers, In-calf; bred by himself.

Commendations.

The mark * signifies "HIGHLY COMMENDED;" the mark † "COMMENDED" (distinctly and individually); and the omission of these marks, "GENERALLY COMMENDED" (as part of a whole class).

*HENRY AMBLER, of Watkinson Hall, Halifax: for his 2 years and 6 months-old Short-horned Roan Bull "Grand Turk;" bred by S. E. Bolden, of Springfield Hall, Lancaster.

*LIEUT.-COLONEL CHARLES TOWNELEY, of Towneley Park: for his 2 years 6 months and 8 days-old Short-horned Red Bull "Voltigeur;" bred by himself.

*LIEUT.-COLONEL CHARLES TOWNELEY: for his 1 year and 7 months-old Short-horned Roan Bull "Richard Cœur de Lion;" bred by himself.

*JOHN BOOTH, of Killerby: for his 5 years and 10 months-old Short-horned Roan Cow "Victrix," In-milk; bred by himself.

*LIEUT.-COLONEL CHARLES TOWNELEY, of Towneley Park: for his 2 years and 10 months-old Short-horned Red-and-White Heifer, In-calf; bred by himself.

*LIEUT.-COLONEL CHARLES TOWNELEY: for his 1 year and 8 months-old Short-horned Red-Roan Heifer "Victoria;" bred by himself.

*WILLIAM FLETCHER, of Radmanthwaite, near Mansfield, Notts: for his 1 year 5 months and 3 weeks-old Short-horned White Heifer "Laura;" bred by himself.

†WILLIAM FLETCHER, of Radmanthwaite: for his 3 years 3 months 2 weeks and 6 days-old Short-horned Roan Bull "Champion;" bred by himself.

†JOHN CARTMELL, of Moss-side, Lytham, Lancashire: for his 3 years 3 months and 3 weeks-old Short-horned Red-and-White Bull "The Sheriff;" bred by himself.

†FRANCIS FOWLER, of Henlon, near Baldock, Beds: for his 1 year 10¾ months-old Short-horned Roan Bull "Duke of Bedford;" bred by himself.

†VISCOUNT HILL, of Hawkstone: for his 11 months-old Short-horned Roan Bull-Calf "Hotspur;" bred by himself.

†ROBERT JEFFERSON, of Preston Hows, Whitehaven: for his 6 months and 1 day-old Short-horned Red Bull-Calf "Cherry Duke;" bred by S. E. Bolden, of Springfield Hall, Lancaster.

†RICHARD STRATTON, of Broad-Hinton, Swindon: for his 4 years and 3 months-old Short-horned Roan Cow "3rd Duchess of Gloucester," In-milk and In-calf; bred by himself.

†RICHARD STRATTON, of Broad-Hinton: for his 4 years and 5 months-old Short-horned Roan Cow "Matchless the 2nd," In-milk and In-calf; bred by himself.

†THOMAS MOORHOUSE, of Newton-Rigg, Penrith: for his 5 years 3 months and 10 days-old Short-horned Light-Roan Cow; bred by himself.

†RICHARD STRATTON, of Broad-Hinton: for his 2 years and 4 months-old Short-horned Roan Heifer "Salthorp Rose 3rd," In-calf: bred by himself.

†VISCOUNT HILL, of Hawkstone: for his 1 year 6 months and 1 day-old Short-horned Roan Heifer "Heresy;" bred by himself.

†RICHARD STRATTON, of Broad-Hinton: for his 1 year and 6 months-old Short-horned Roan Heifer "Marcia 3rd;" bred by himself.

†JOHN SAMUEL CRAWLEY, of Stockwood, near Luton: for his 1 year 5 months and 8 days-old Short-horned Roan Heifer "Gretna;" bred by himself.

†STEWART MARJORIBANKS, of Bushey-grove, Watford: for his 1 year 1 month and 2 weeks-old Short-horned Roan Heifer "Sunflower;" bred by himself.

†GEORGE SAINSBURY, of the Priory, Corsham, Wilts: for his 1 year and 4 months-old Short-horned Red-and-White Heifer "Little Flirt;" bred by himself.

*WILLIAM STYLES POWELL, of Hereford: for his 2 years and 7 months-old Hereford Red-Brown White-faced Bull "Brecon;" bred by Walter Maybery, of Brecon.

*RICHARD HILL, of Golding Hall, Shrewsbury: for his 3 years and (nearly) 5 months-old Hereford Grey Bull "Restorative;" bred by Henry Hill, of Stableford House, Bridgenorth.

*JOHN MONKHOUSE, of the Stow, Hereford: for his 3 years and 6 months-old Hereford White-faced Red Bull "Madoc;" bred by James Rea, of Monaughty, Knighton.

†James Ackers, of Prinknash Park, Painswick: for his 5 years 8 months and 11 days-old Hereford White-faced very Dark-Red Cow "Beauty," In-milk and In-calf; bred by himself.

William Perry, of Cholstrey, Leominster: for his 2 years and 11 months-old Hereford White-faced Red Bull "Goldfinder 2nd;" bred by John Perry, of Much-Cowarn, Bromyard.

Walter Maybery, of Brecon: for his 3 years 2 months and 3 days-old Hereford Brown-and-White Bull "Prince of Wales;" bred by himself.

Lord Berwick, of Cronkhill: for his 2 years and 5 months-old Hereford White-faced Red Bull; bred by himself.

William Taylor, of Showle Court, Hereford: for his 2 years and 6 months-old Hereford White-faced Red Bull "Triton;" bred by himself.

John Walker, of Westfield House, Holmer: for his 3 years and 8 months-old Hereford White-faced Red Bull "Holmer;" bred by himself.

Edward Price, of Court House, Pembridge, Leominster: for his 1 year and 4 months-old Hereford Red-and-White Heifer "Primrose;" bred by himself.

Edward Price, of Court House: for his 1 year and 5 months-old Hereford Red-and-White Heifer "Silver;" bred by himself.

William Racster, of Kinghill Court, Hereford: for his 1 year 7 months and 5 days-old Hereford White-faced Red Heifer "Miss David Hampton Pigeon;" bred by himself.

William Racster, of Kinghill Court: for his 1 year 8 months and 9 days-old Hereford Red Heifer "Miss David Chance," with white face and white mane or cress; bred by himself.

*Walter Farthing, of Stowey Court, Bridgewater: for his 6 years and 3½ months-old Devon Red Cow "Punch," In-milk and In-calf; bred by the late Samuel Farthing, of Stowey Court.

*Walter Farthing, of Stowey Court: for his 2 years and 4½ months-old Devon Red Heifer "Fancy," In-calf; bred by the late Samuel Farthing.

*Thomas Webber, of Halberton Court, Tiverton: for his 2 years and 7 months-old Devon Red Heifer "Princess," In-calf; bred by himself.

†Walter Farthing, of Stowey Court: for his 3 years and 2½ months-old Devon Red Bull "Duke of Somerset;" bred by John K. Farthing, of Stowey.

†Thomas Webber, of Halberton Court: for his 1 year and 7 months-old Devon Red Heifer "Young Curly;" bred by himself.

†William Muir, of Hardington Mains, Lanarkshire: for his 2 years and 4 months-old Ayrshire Brown-and-White Heifer "Lily;" bred by Thomas Fleming, of Corson, Edinburgh.

*Nathaniel George Barthropp, of Cretingham Rookery, Woodbridge: for his 2 years-old Suffolk Chesnut Filly; bred by himself.

*Benjamin Weir, of Dalston, Carlisle: for his 6 years-old Clydesdale Grey Stallion "Young Conqueror;" bred by George Blaylock, of Burgh-by-Sands, near Carlisle.

*William Sanday, of Holmepierrepoint: for his 17 months-old Leicester Ram; bred by himself.

*William Sanday, of Holmepierrepoint: for his 40 months-old Leicester Ram; bred by himself.

†Thomas Edward Pawlett, of Beeston: for his 15 months-old Leicester Ram; bred by himself.

†William Sanday, of Holmepierrepoint: for his 17 months-old Leicester Ram; bred by himself.

†Thomas Edward Pawlett, of Beeston: for his 27 months-old Leicester Ram; bred by himself.

†William Sanday, of Holmepierrepoint: for his 40 months-old Leicester Ram; bred by himself.

†William Rigden, of Hove: for his 16½ months-old Southdown Ram; bred by himself.

†Henry Lugar, of Hengrave: for his 16 months-old Southdown Ram; bred by himself.

†Lord Walsingham, of Merton Hall: for his pen of five 15½ months-old Southdown Ewes; bred by himself.

*George Fletcher, of Shipton, Gloucester: for his 28 months-old Cotswold Ram; bred by himself.

†William Hewer, of Northleach: for his 16 months-old Cotswold Ram; bred by himself.

†William Lane, of Broadfield Farm, Northleach: for his 16 months-old Cotswold Ram; bred by himself.

†Thomas Beale Browne, of Hampen, Gloucestershire: for his 28½ months-old Cotswold Ram; bred by himself.

†James Walker, of Northleach: for his 28 months-old Cotswold Ram; bred by himself.

†Thomas Beale Browne, of Hampen, Gloucestershire: for his Pen of five 16 months-old Cotswold Ewes; bred by himself.

†George Fletcher, of Shipton, Gloucestershire: for his Pen of five 16 months-old Cotswold Ewes; bred by himself.

†Lord De Mauley (deceased), of Hatherop Castle: for his Pen of five 15 months-old Cotswold Ewes; bred by himself.

**William Jopson, of High House, Staveley, near Kendal: specially commended, for his 4 years and 10 months-old White Breeding-Sow "Miss Windsor," of the Coleshill small breed; bred by Henry Scott Hayward, of Folkington, near Willingdon, Sussex.

*Thomas Horsfall, of Burley Hall, Otley: for his 3 years 3 months and 1 week-old Yorkshire large White Breeding-Sow "Helena;" bred by himself.

*George Turner, of Barton, Exeter: for his 1 year 10 months and 2 weeks-old Improved-Essex small Black Breeding-Sow; bred by Richard Melhuish, of Worlington, near Wetheridge.

*Thomas Horsfall, of Burley Hall: for his 1 year 5 months and 3 weeks-old Yorkshire small White Breeding-Sow; bred by himself.

*William Bradley Wainman, of Carhead, Cross Hills, near Leeds: for his Pen of three 4 months and 2 days-old White Breeding-Sows, of the Improved Yorkshire large breed; bred by himself.

*Jonathan Brown, of the Height, Wigton: for his Pen of three 6 months and 2 weeks-old White Breeding-Sows, of a small breed; bred by himself.

†James Farish, of Dormansteads, Carlisle: for his 3 years and 8 months-old Cumberland Breeding Sow, White with a single Grey spot and of a large breed; bred by himself.

†William Bradley Wainman, of Carhead, near Leeds: for his 3 years 5 months and 2 weeks-old Improved Yorkshire large White Breeding-Sow "Lady Airedale;" bred by J. Barker, of Glasburn, Keighley.

†George Mangles, of Givendale, Ripon: for his 1 year 2 months and 2 weeks-old Yorkshire small White Breeding-Sow "2nd Queen of Diamonds;" bred by himself.

†Henry Scott Hayward, of Folkington, near Willingdon, Sussex: for his 10 months and 2 weeks-old small White Breeding-Sow; bred by himself.

*Thomas Elliot, of Hindhope, Roxburghshire: for his 38 months-old Cheviot Ram; bred by himself.

*William Aitchison, of Linhope, near Hawick: for his 3 years and 3 months-old Cheviot Ram; bred by J. Brydon, of Moodlaw, near Langholm.

*Thomas Elliot, of Hindhope: for his 14 months-old Cheviot Ram; bred by himself.

*William Aitchison, of Linhope: for his 14½ months-old Cheviot Ram; bred by himself.

†John Carruthers, of Kirkhill, Dumfriesshire: for his 27 months-old Cheviot Ram; bred by himself.

†Thomas Charles Borthwick, of Hopsrig, Dumfriesshire: for his 1 year and 3 months-old Cheviot Ram; bred by himself.

Thomas Sibson, of Grinsdale, Carlisle: for his 3 years-old Dark Grey Cart-Filly; bred by Joseph Jefferson, of Greenrig, near Wigton.

William Stordy, of Moorhouse, Carlisle: for his 3 years-old Grey Cart-Filly "Darling;" bred by himself.

Richard Bowman, of Forest Hill, Penrith: for his 3 years and 3 weeks-old Brown Cart-Filly "Jin;" bred by James Davidson, of Hall Hills, Cumberland.

William Bainbridge, of Newbiggin, Penrith: for his 3 years and 1½ month-old Black Cart-Filly "Fan;" bred by Isaac Bainbridge, of Skelton, Penrith.

James Douglas, of Athelstaneford Farm, Drem: for his 3 years and 2 months-

old Clydesdale Brown Cart-Filly "Molly;" bred by J. Galbraith, of Campsie.

William Graham, of Laws Town, Canonbie, Cumberland: for his 2 years-old Brown Cart-Filly "Jessy;" bred by himself.

†John Sutton, of Wood Head, Scaleby, Carlisle: for his 2 years and 11½ months-old Galloway Black Bull "Adonis;" bred by the late Walter Irving.

William Talbot Rothwell, of Foxholes, Lancaster: for his 6 years-old Dark-brown Thorough-bred Stallion "Emerystone;" bred by himself.

Hepworth and Wilson, of Langrick Ferry, Selby, Yorkshire: for their 15 years-old Brown Thorough-bred Stallion "The Era;" bred by Richard Watts, of Bishop-Burton, Beverley.

Robert and James Moffitt, of Newtown, Rockcliff, Carlisle: for their 15 years-old Dark-Brown Thorough-bred Stallion "A British Yeoman;" bred by J. Blacklock, of Harts, Yorkshire.

Benjamin Weir, of Dalston, Carlisle: for his 4 years-old Brown Thorough-bred Stallion "Larriston;" bred by J. Stebbings, of Hambleton.

James Fairburn, of Goshen Cottage, Kelso: for his 7 years-old Brown Thorough-bred Stallion "Cyclops;" bred by Sir G. H. Boswell, Bart., of Blackadder House, Berwickshire.

Stephen Kirby, of Thirsk, Yorkshire: for his 5 years-old Bay Thorough-bred Stallion "Witton;" bred by himself.

Henry Scott Waring, of Darlington: for his 21 years-old Brown Thorough-bred Stallion "St. Bennett;" bred by the late H. Vansittart, of Kirkleatham Hall.

John Ashton, of Brigg: for his 14 years-old Bay Thorough-bred Stallion "The Cure;" bred by William Wetherell, of Kirkbridge, Richmond, Yorkshire.

William Sharpe, of Knockhill, Dumfriesshire: for his 9 years-old Bay Thorough-bred Stallion "Turnus;" bred by Count Hahn, of Germany.

James Wilkin, of Tinwald Downs, Dumfriesshire: for his 17 years-old Dark-Bay or Brown Thorough-bred Stallion "Vulcan;" bred by the late J. Johnston, near Manchester.

John Etudge Wilkinson, of Wickham Hill, Durham: for his 6 years-old Brown Thorough-bred Stallion "Burndale;" breeder unknown.

Villiers, C. V. Surtees, of Newcastle-on-Tyne: for his 7 years-old Bay Thorough-bred Stallion "Colsterdale;" bred by Admiral Harcourt.

*Jonathan Brown, of The Height, Wigton: for his 2 years and 2 months-old Silver-grey Dorking Cock, bred by John Alderson, of Thornby Villa; and two Hens, bred by the exhibitor.

*John Robinson, of Orton Hall, Westmoreland: for his 1 year and 3 months-old single-combed silver-grey Dorking Cock, bred by the exhibitor; and two Hens, bred by Sir T. G. Hesketh, Bart.

*Mrs. Thomas Townley Parker, of Astley Hall, Chorley; for a 2 years and 2 months-old coloured Dorking Cock, and two 1 year 2 months and 2 weeks-old coloured Dorking Hens; bred by herself.

*Mrs. Thomas Townley Parker: for a 1 year 1 month and 1 week-old Dorking Cock; bred by herself.

*Miss Rebecca Bell, of Woodhouselees, Dumfriesshire: for a 1 year and 3 months-old Black Spanish Cock; bred by herself.

*Henry Daniel Davies, of Spring-Grove House: for his 2 months and 3 weeks-old Toulouse Gander and two Geese; bred by himself.

*John Stamper, of Newton, Penrith: for his 3 years 1 month and 2 weeks-old white-swan Gander and two Geese; bred by himself.

William Bownass, of the Royal Hotel, Bowness: for his 3 months and 2 weeks-old grey Dorking Cock and two Pullets; bred by himself.

Mrs. Hanbury, of Thorn Bank, Leamington: for her 3 months-old grey Dorking Cock and two Pullets; bred by herself.

Daniel Harrison, of Singleton Park, Kendal: for his 2½ months-old grey or coloured Dorking Cock and two Pullets; bred by himself.

Mrs. Warburton, of Kill, near Naas, Kildare: for her 5 months-old grey-speckled Dorking Cock and two Pullets; bred by John Baily, of London.

Mrs. Warburton, of Kill: for her 5 months-old grey-speckled Dorking Cock and two Pullets; bred by John Baily.

EDWARD AKROYD, of Denton Park, Otley: for his 2 months-old grey or silver Dorking Cock and two Pullets; bred by himself.

JOHN ROBINSON, of Orton Hall, Westmoreland: for his 2 months and 1 week-old single-combed silver-grey Dorking Cock and two Pullets; bred by himself.

THOMAS ULLOCK, of Quarry House, Windermere: for his 2 months and 3 weeks-old silver-grey Dorking Cock, and two 4 months-old Pullets; bred by himself.

JOHN ROBINSON, of Orton Hall: for his 2 months and 3 weeks-old rose-combed white Dorking Cock and two Pullets; bred by himself.

HENRY DANIEL DAVIES, of Spring-Grove House: for his 5 months and 2 weeks-old coloured Dorking Cock and two Pullets: bred by himself.

HENRY BOLCKOW, of Marton Hall: for his 2 months and 2 weeks-old Dorking Cock and two Pullets; bred by himself.

GEORGE CALEB ADKINS, of West House: for his 1 year and 2 months-old grey Dorking Cock and two Hens; breeder unknown.

WILLIAM BOWNASS, of Bowness: for his 1 year 3 months and 1 week-old grey Dorking Cock, bred by himself, and two Hens, bred by Thomas Ullock, of Bowness.

JOHN KERSLEY FOWLER, of Prebendal Farm, Aylesbury: for his 1 year and 2 months-old grey or speckled Dorking Cock and two Hens; bred by the Rev. J. Boys, of Biddenden, Kent.

DANIEL HARRISON, of Singleton Park: for his 2 years and 3 months-old light-grey Dorking Cock, bred by Thomas Ullock, of Quarry House, Windermere; and his two 1 year and 3 months-old light-grey Dorking Hens, bred by James Lewry, of Handcross, Sussex.

JOSEPH HINDSON, of Barton House, near Liverpool: for his 1 year 3 months and 2 weeks-old grey Dorking Cock and 2 Hens; bred by himself.

ISAAC LAWSON, of Holme House, Carlisle: for his 2 years and 2 months-old grey Dorking Cock, bred by himself; and his two 1 year and 3 months-old grey Dorking Hens, bred by W. Ellison, of Sizergh, Kendal.

Mrs. WARBURTON, of Kill: for her 1 year and 1 month-old grey Dorking Cock, bred by John Baily, of London; and two Hens, bred by Henry Smith, of The Grove, Cropwell-Butler, near Bingham.

EDWARD AKROYD, of Denton Park: for his 1 year and 3 months-old grey or silver Dorking Cock and two Hens; bred by himself.

EDWARD AKROYD, of Denton Park: for his 1 year and 3 months-old grey or silver Dorking Cock and two Hens; breeder unknown.

SAMUEL SWAN, of Bush, Roxburghshire: for his 1 year and 1 month-old silver Dorking Cock and two Hens; bred by Thomas Penny, of Bartlehill, Kelso.

LEONARD WILSON ATKINSON, of Newbiggin, Hexham; for his 2 or 3 years-old white Dorking Cock and two Hens; bred by himself.

Miss REBECCA BELL, of Woodhouselees: for her 1 year and 3 months-old coloured single-combed Dorking Cock and two Hens; bred by herself.

Miss REBECCA BELL, of Woodhouselees: for her 1 year and 3 months-old coloured single-combed Dorking Cock and two Hens; bred by herself.

GEORGE ATKINSON GELDERD, of Aikrigg End; for his 5 years and 3 months-old coloured Dorking Cock, bred by Thomas Townley Parker, of Astley Hall; and two Hens, bred by the exhibitor.

Lord ROBERT GROSVENOR, M.P., of Moor Park, Herts: for his 1 year-old coloured Dorking Cock, bred by himself; and his two (about) 2 years-old coloured Dorking Hens, bred by Edward Terry, of Aylesbury.

EDWARD LISTER, of Cassia Lodge, Northwich: for his (about) 2 years-old coloured Dorking Cock and two Hens; bred by himself.

Mrs. THOMAS TOWNLEY PARKER, of Astley Hall: for her 1 year and 3 months-old coloured Dorking Cock and two Hens; bred by herself.

WILLIAM TOD, of Elphinstone Tower, East Lothian: for his 1 year and 3 months-old Dorking Cock and two Hens: bred by himself.

JOSEPH ALLISON, of Friar's Place, Acton: for his (above) 12 months-old white-faced black Spanish Cock and two Hens; breeder unknown.

JOSEPH ALLISON, of Friar's Place: for his (above) 12 months-old white-faced black Spanish Cock and two Hens; breeder unknown.

JAMES FREDERICK DIXON, of Cotgrave, Nottingham: for his 2 years 1 month and 2 weeks-old white-faced Spanish Cock and two Hens; breeder unknown.

William Lightfoot, of Shield Field: for his 2 years and 1 month-old white-faced black Spanish Cock and two Hens; bred by Captain Hornby, R.N.

Sir John Heron Maxwell, Bart., of Springkell, Dumfriesshire: for his 2 years and 2 weeks-old white-faced Spanish Cock and two Hens; bred by B. Barker, of Wyseby Hill, Ecclefechan.

Augustus George Ogilvy, of Solway House, Carlisle: for his 2 years and 2 months-old white-faced black Spanish Cock and two Hens; bred by himself.

Matthew Ridgway, of Dewsbury, Yorkshire: for his (about) 2 years-old white-faced black Spanish Cock and two Hens; bred by himself.

Miss Rebecca Bell, of Woodhouselees: for her 1 year and 2 months-old black Spanish Cock and two Hens; bred by herself.

George Caleb Adkins: for his (about) 2 years-old black-breasted red Game-Cock and two Hens; breeder unknown,

Henry Beldon, of Prospect Place, Eccleshill Moor, Bradford: for his 1 year and 11 months-old black-breasted red Game-Cock, and his 1 year and 2 months-old Game Hens; bred by Benjamin Thornton, of Eccleshill Moor.

Daniel Harrison, of Singleton Park: for his 1 year and 2 months-old black-breasted red Game Cock and two Hens; bred by the Earl of Derby, Knowsley.

James Dixon, of North Park: for his 2 years-old red Game Cock and two Hens; breeder not stated.

William Geddes, of Harker, Carlisle: for his 2 years-old black-red Game Cock and two Hens; bred by himself.

George Hudson, of Newcastle-on-Tyne: for his 2 years and 2 months-old black-red Game Cock and two Hens; bred by himself.

William Rowell, of Haydon Bridge, Northumberland: for his 3 years and 2 months-old black-red Game Cock and two Hens; bred by himself.

Edward Akroyd, of Denton Park: for his 3 years and 3 months-old black Game Cock, breeder unknown; and his 1 year and 3 months-old black Game Hens, bred by himself.

Matthew Ridgway, of Dewsbury: for his 2 years-old black Game Cock, and his two 1 year-old black Game Hens; breeder unknown.

James Douglas, of Athelstaneford Farm: for his 1 and 2 years-old blue Game Cock and two Hens; bred by himself.

Robert Pickthall, of Mint House: for his (about) 3 years and 2 months-old blue-red Game Cock and two Hens; bred by J. K. Hodgson, of Ulverston.

Wood and Hollings, of Horton, Bradford: for their (about) 1 year-old bright-red Game Cock and two Hens; breeder unknown.

John Wright, of Hulland Hall: for his 1 year and 3 months-old duckwing-grey Game Cock and two Hens; bred by himself.

Daniel Leeming, of Blackwood House, Halifax: for his 1 year and 2 months-old duckwing Game Cock and two Hens; bred by himself.

William Ellison, Jun., of Low Sizergh, Milnthorp: for his 2 years and 3 months-old piles Game Cock and two Hens; bred by William Wilkinson, of Brigstern, Milnthorp.

William Ellison, Jun.: for his 2 years and 2 months-old piles Game Cock and two Hens; bred by William Wilkinson.

William Corrie, of Darn Side, Wigton: for his 3 years-old Game Cock, and 2 years-old Game Hens; bred by himself.

James Dixon, of North Park, Bradford: for his 1 year-old Aylesbury Drake and two Ducks; bred by himself.

John Robinson, of Orton Hall: for his 1 year and 2 months-old white Aylesbury Drake and two Ducks; breeder unknown.

Henry Ambler, of Watkinson Hall: for his 2 years and 3 weeks-old pure white-billed Aylesbury Drake and two Ducks; bred by himself.

Edward Akroyd, of Denton Park: for his 1 year 2 months and 2 weeks-old white Aylesbury Drake and two Ducks; bred by himself.

Samuel Swan, of Bush, Roxburghshire: for his 1 year 2 months and 3 weeks-old common Aylesbury Drake and two Ducks; bred by himself.

William Tod, of Elphinstone Tower: for his 1 year and 2 months-old Aylesbury Drake and two Ducks; bred by himself.

Leonard Wilson Atkinson, of Newbiggin, Hexham: for his 1 and 2 years-old white Aylesbury Drake and two Ducks; one bred by J. Trotter, of Bywell, and one by the exhibitor; the breeder of the other unknown.

Daniel Leeming, of Halifax: for his 1 year and 2 months-old white-billed Aylesbury Drake and two Ducks; bred by himself.

George Atkinson Gelderd, of Aikrigg End: for his 9 weeks-old Aylesbury Drake and two Ducks; bred by himself.

William Lort, of Great Heath, Tenbury: for his 1 year and 1 month-old Aylesbury Drake and two Ducks; bred by himself.

John Waugh, of Warwick Bridge, Carlisle: for his 1 year and 1 month-old Aylesbury Drake and two Ducks; bred by himself.

The mark * signifies "highly commended;" the mark † "commended" (distinctly and individually); and the omission of these marks, "generally commended" (as part of a whole class).

IMPLEMENTS.

The Society having offered a Prize of Two Hundred Pounds "for the Steam-Cultivator that shall in the most efficient manner turn the Soil, and be an economical substitute for the Plough, or the Spade," the Judges in that Division, at the Carlisle Meeting, made the following entry on the Award-Sheet:—

Steam-Cultivator.—"The Judges are of opinion that no implement has been exhibited which fulfils the terms and conditions on which the Society's Prize is offered; and such Prize is therefore withheld."

Ransomes and Sims, of Ipswich: the Prize of Five Sovereigns, for their Two-wheeled Iron Plough, marked Y R C, as the Plough best adapted for general purposes; invented, improved, and manufactured by themselves.

Ransomes and Sims, of Ipswich: the Prize of Five Sovereigns, for their Two-wheeled Solid-Beam Iron Plough, marked Y R S, as the Plough best adapted for ploughing more than 9 inches deep; invented, improved, and manufactured by themselves.

John Whitehead, of Preston: the Prize of Five Sovereigns, for his Drain Tile and Pipe Machine; invented, improved, and manufactured by himself.

Richard Coleman, of Chelmsford: the Prize of Five Sovereigns, for his Drag-Harrow, Cultivator, or Scarifier; invented and manufactured by himself.

Richard Garrett and Son, of Leiston, Saxmundham: the Prize of Ten Sovereigns, for their Drill for general purposes; invented, improved, and manufactured by themselves.

Richard Hornsby and Son, of Spittlegate, Grantham: the Prize of Ten Sovereigns, for their Drill for Corn and Seeds; invented, improved, and manufactured by themselves.

Richard Hornsby and Son, of Spittlegate, Grantham: the Prize of Five Sovereigns, for their Corn-Drill for small occupations; invented, improved, and manufactured by themselves.

Holmes and Sons, of Norwich: the Prize of Five Sovereigns, for their Seed and Manure Drill for Small-Occupations, on the flat or ridge; invented, improved, and manufactured by themselves.

Richard Garrett and Son, of Leiston, Saxmundham: the Prize of Five Sovereigns, for their Turnip-Drill, on the flat, with manure; improved and manufactured by themselves.

Richard Hornsby and Son, of Spittlegate, Grantham: the Prize of Five Sovereigns, for their Turnip-Drill, on the ridge, with manure; invented, improved, and manufactured by themselves.

Robert and John Reeves, of Bratton, Westbury, Wiltshire: the Prize of Ten Sovereigns, for their Liquid-Manure-Drill; invented by Thomas Chandler, of Aldbourne; and improved and manufactured by themselves.

RICHARD GARRETT and SON, of Leiston, Saxmundham: the Prize of TEN SOVEREIGNS, for their Broadcast Manure-Distributor; invented by Thomas Chambers, jun., of Colkirk Hall, Fakenham; and improved and manufactured by themselves.

RICHARD GARRETT and SON, of Leiston, Saxmundham: the Prize of FIVE SOVEREIGNS, for their Horse-Hoe, on the flat; invented, improved, and manufactured by themselves.

RICHARD GARRETT and SON, of Leiston, Saxmundham: the Prize of FIVE SOVEREIGNS, for their Horse-Hoe and Turnip-thinner, on the ridge and flat; invented by Thomas Huckvale, of Choice Hill, Chipping-Norton; and improved and manufactured by themselves.

BURGESS and KEY, of Newgate Street, London: the Prize of THIRTY SOVEREIGNS, for the best Reaping-Machine; invented by Cyrus Hall MacCormick, of Chicago, United States of America; improved by their Archimedean-Screw-Platform, and manufactured by themselves.

JOHN PALMER, of Stockton-on-Tees: the Prize of TWENTY SOVEREIGNS, for his Combined Reaping and Mowing Machine, as the second-best Reaping-Machine; invented by Forbush and Co., of Buffalo, United States of America; improved by the Exhibitor, and manufactured by Forbush and Co. and the Exhibitor.

TUXFORD and SONS, of Boston: the Prize of TWENTY SOVEREIGNS, for their Eight-horse Power Portable Steam-Engine; invented by Weston Tuxford, of Boston, and manufactured by themselves.

CLAYTON, SHUTTLEWORTH, and Co., of Lincoln: the Prize of TEN SOVEREIGNS, for their Eight-horse Power Portable Steam-Engine; invented, improved, and manufactured by themselves.

RANSOMES and SIMS, of Ipswich: the Prize of TWENTY SOVEREIGNS, for their Eight-horse Power Horizontal Direct-action Fixed Steam-Engine; invented and manufactured by themselves.

BARRETT, EXALL, and ANDREWES, of Reading: the Prize of TEN SOVEREIGNS, for their Eight-horse Power Horizontal Fixed Steam-Engine; invented, improved, and manufactured by themselves.

RANSOMES and SIMS, of Ipswich: the Prize of TEN SOVEREIGNS, for their Portable Steam Thrashing-Machine, under Six-horse power, with shaker and riddle; invented, improved, and manufactured by themselves.

RICHARD HORNSBY and SON, of Spittlegate, Grantham: the Prize of TWENTY SOVEREIGNS, for their Portable Combined Thrashing, Shaking, and Dressing Machine; invented, improved, and manufactured by themselves.

CLAYTON, SHUTTLEWORTH, and Co., of Lincoln: the Prize of TWENTY SOVEREIGNS, for their Set of Fixed Barn-Works; invented, improved, and manufactured by the Exhibitors.

RICHARD HORNSBY and SON, of Spittlegate, Grantham: the Prize of FIVE SOVEREIGNS, for their Corn-Dressing or Winnowing Machine; invented, improved, and manufactured by themselves.

CLAYTON, SHUTTLEWORTH, and Co., of Lincoln: the Prize of FIVE SOVEREIGNS, for their Grinding-Mill, consisting of a pair of Portable Derbyshire Mill-Stones, driven by steam-power; invented, improved, and manufactured by themselves.

EDWARD R. and FREDERICK TURNER, of Ipswich: the Prize of FIVE SOVEREIGNS, for their Linseed and Corn Crusher; invented by Bond, Turner, and Hurwood, and improved and manufactured by the Exhibitors.

JAMES CORNES, of Barbridge, near Nantwich: the Prize of FIVE SOVEREIGNS, for his Chaff-cutter worked by horse or steam power; invented by John Cornes, sen., and improved and manufactured by the Exhibitor.

RICHMOND and CHANDLER, of Salford, Manchester: the Prize of THREE SOVEREIGNS, for their Hand Chaff-Cutter; invented, improved, and manufactured by themselves.

BERNHARD SAMUELSON, of Banbury: the Prize of THREE SOVEREIGNS, for a Double-action Turnip-Cutter; invented by the late James Gardner, improved by Alexander Samuelson, and manufactured by the Exhibitor.

PHILLIPS and WOODS, of Brandon and Stowmarket: the Prize of THREE SOVEREIGNS, for their Hand Root and Mincing-Machine; invented and improved by Frederick Phillips of Brandon, and manufactured by James Woods of Stowmarket.

RICHARD GARRETT and SON, of Leiston, Saxmundham: the Prize of FIVE SOVEREIGNS, for their Cake-Breaker, adapted for every variety of Cake; improved and manufactured by themselves.

ALFRED CROSSKILL, of Beverley: the Prize of FIVE SOVEREIGNS, for his Three-horse Power Excentric Mill for grinding Bones, &c.; improved by William Crosskill, and manufactured by the Exhibitor.

BURGESS and KEY, of Newgate Street, London: the Prize of THREE SOVEREIGNS, for their American Churn; invented by C. J. Anthony of the United States; and improved and manufactured by themselves.

MEDALS.

CLAYTON, SHUTTLEWORTH, and Co., of Lincoln: a SILVER MEDAL, for their adaptation of an Improved Revolving Screen, which "separates the tail from the good corn; and in one operation, in addition to thrashing, prepares and puts the corn into bags fit for market;" invented, improved, and manufactured by themselves (see "Commendations").

WILLIAM DRAY and Co., of Swan Lane, London: a SILVER MEDAL, for their Grain and Seed Separator; invented by G. B. Salmon, Illinois; and improved and manufactured by themselves.

RANSOMES and SIMS, of Ipswich: a SILVER MEDAL, for their Subsoil and Trench Plough; invented and improved by Robert Cotgreave of Ipswich, and manufactured by themselves.

JOHN PALMER, of Stockton-on-Tees: a SILVER MEDAL, for his Compound-action Clod-Crusher and Roller; invented by John Patterson of Beverley; improved by John Patterson of Beverley, and Brown (Brothers) of Stockton-on-Tees; and manufactured for the Exhibitor by Brown (Brothers) of Stockton-on-Tees.

JAMES BOYDELL, of Camden-Town, London: a SILVER MEDAL, for his Wheels fitted with an Endless Railway; invented and improved by himself; and manufactured by Boydell and Glasier, of Camden Works.

RICHARD GARRETT and SON, of Leiston, Saxmundham: a SILVER MEDAL, for their improved Barley-Hummeller, connected with their Fixed Barn-Works; invented, improved, and manufactured by themselves (see "Commendations").

ROBERT HUNT, of Earl's Colne, Essex: a SILVER MEDAL, for his improved Machine or Engine, for Drawing Clover and Trefoil seed; improved and manufactured by himself.

WILLIAM COULSON, of Fetter-Lane, York: a SILVER MEDAL, for his Combined Machine for Boring and Mortising; invented and manufactured by himself (see "Commendations").

ALFRED CROSSKILL, of Beverley: a SILVER MEDAL, for his improved Clod-Crusher, or Serrated Roller; invented and improved by William Crosskill, and manufactured by the Exhibitor.

WILLIAM PIERCE, late of 73, Mark-Lane, London: a SILVER MEDAL, for his Spring-Shaft Car, or Chaise-Cart; invented by the Rev. Frederick Glover, of London, and manufactured by the Exhibitor. The Judges have remarked in making this award:—"This car has peculiarly con-

structed shafts which claimed the attention of both Stewards and Judges of Implements. It has claims to novelty and originality of build. Without the ordinary steel springs usually found in carriages, it carried with ease and comfort, and without a jolt, a party of six from the show-yard at Carlisle to the trial-field, and over a rough road, that would have placed common steel springs in danger. The principle of the shafts is new, and may be applied to any kind of cart, particularly market-carts and Whitechapels."

Commendations.

The mark * signifies "HIGHLY COMMENDED;" the mark † "COMMENDED," by the Judges.

*JAMES and FREDERICK HOWARD, of Bedford: for their Two-wheeled Iron Plough, marked PP No. 2, adapted for general purposes; invented and manufactured by themselves.

†WILLIAM BUSBY, of Newton-le-Willows, Yorkshire: for his Two-wheeled Plough, for general purposes; invented, improved, and manufactured by himself.

†WILLIAM BALL, of Rothwell, Northamptonshire: for his Iron Plough, for general purposes; invented, improved, and manufactured by himself.

*WILLIAM BUSBY, of Newton-le-Willows: for his Two-wheeled Deep Plough: invented, improved, and manufactured by himself.

†JAMES and FREDERICK HOWARD, of Bedford: for their Two-wheeled Iron Plough, marked PPP, adapted for extra-deep ploughing; invented and manufactured by themselves.

†WILLIAM BALL, of Rothwell: for his Iron Plough, calculated for deep ploughing; invented, improved, and manufactured by himself.

*THOMAS SCRAGG, of Calveley, Cheshire: for his Single-Action Tile-Machine; invented and manufactured by himself.

†PORTER, HINDE, and PORTER, of Carlisle: for their Brick-Machine, with Pug-Mill combined; improved by John Francis Porter, C.E., and manufactured by themselves.

*EDWARD HAMMOND BENTALL, of Heybridge, Essex: for his Iron-beam light Broadshare Plough, *as a broadshare;* invented and manufactured by himself.

†RANSOMES and SIMS, of Ipswich: for their Wrought-iron Scarifier, Grubber, or Cultivator, *as a cultivator, grubber, and scarifier;* invented by Arthur Biddell; improved and manufactured by themselves.

†WILLIAM BALL, of Rothwell: for his Press-Corn-Drill, on the flat, "pressing grooves and depositing the seed on a solid bottom;" invented and manufactured by himself.

*JAMES and FREDERICK HOWARD, of Bedford: for their Land-Presser, or Drill-Presser, "intended to follow three ploughs, and, in addition to pressing the furrows, to deposit and cover the seed at one operation on the firm bottom obtained;" invented by G. W. Baker, of Woburn Park Farm, and manufactured by themselves.

†ROBERT SEWELL, of Longtown, Cumberland: for his Drill-Grubber and Horse-Hoe combined; improved and manufactured by himself.

*RICHARD HORNSBY and SON, of Spittlegate, Grantham: for their Drill for Corn and General Purposes; invented, improved, and manufactured by themselves.

*RICHARD GARRETT and SON, of Leiston, Saxmundham: for their Lever Corn and Seed Drill; improved and manufactured by themselves.

*RICHARD GARRETT and SON, of Leiston: for their Three-rowed Economical Seed and Manure Drill for Turnips, &c., with manure, on the flat or ridge, as a Small-occupation Manure-Drill; invented, improved, and manufactured by themselves.

*RICHARD HORNSBY and SON, of Spittlegate: for their Turnip-Drill on the flat with manure; invented, improved, and manufactured by themselves.

*RICHARD GARRETT and SON, of Leiston: for their Turnip-Drill on the ridge with manure; improved and manufactured by themselves.

RICHARD GARRETT and SON, of Leiston: for their Lever Corn and Seed Drill, as

a Small-Occupation Corn-Drill; invented, improved, and manufactured by themselves.

†James Smyth and Sons, of Peasenhall, Suffolk: for their Small-Occupation Suffolk Lever Corn and Seed Drill; invented, improved, and manufactured by themselves.

*James and Frederick Howard, of Bedford: for their Jointed Iron Harrows, marked No. 10; invented and manufactured by themselves.

†Holmes and Sons, of Norwich: for their Manure-Distributor; invented, improved, and manufactured by themselves.

*James and Frederick Howard, of Bedford: for their Ridge Horse-Hoe; invented and manufactured by themselves.

†William Busby, of Newton-le-Willows: for his Horse-Hoe, with three Tines, and Harrow; commended as a "Ridge Horse-Hoe;" invented, improved, and manufactured by himself.

†William Smith, of Kettering: for his Steerage Horse-Hoe, with double bars; commended as a "Horse-Hoe on the flat;" invented, improved, and manufactured by himself.

†William Lister, of Dunsa Bank, Richmond, Yorkshire: for his new implement "for loosening turnips in the ground, and cutting off the tails;" invented by himself, and manufactured by William Busby, of Newton-le-Willows.

*William Dray and Co., of Swan Lane, London: for their Reaping-Machine, tilting platform, skeleton-knife, leverage for raising and lowering the cut, and wheel to relieve the horses of the weight of the machine; invented by Obed Hussey, of the United States of America; improved and manufactured by themselves.

*Smith and Ashby, of Stamford: for their Double-Action Haymaking Machine, on their own Wrought-iron Wheels; invented, improved, and manufactured by the Exhibitors.

†William Newzam Nicholson, of Newark-upon-Trent: for his Haymaking-Machine, with tubular iron shafts, and the whole of the wearing parts case-hardened; invented, improved, and manufactured by himself.

*James and Frederick Howard, of Bedford: for their Horse-Rake; invented and manufactured by themselves.

†William Williams, of Bedford: for his Horse-Rake; invented by Samuel Taylor of Cotton-End, and improved and manufactured by the Exhibitor.

†Smith and Ashby, of Stamford: for their One-Horse Cart, for harness-work and general purposes; improved and manufactured by themselves.

†Alfred Crosskill, of Beverley: for his Model One-Horse Cart, for general purposes; invented and improved by William Crosskill; and manufactured by the Exhibitor.

†William Busby, of Newton-le-Willows: for his One-Horse Cart; invented and manufactured by himself.

†William Dray and Co., of Swan Lane, London: for their Light One-Horse Waggon; invented, improved, and manufactured by themselves.

†Johnson and Sharman, of Leicester and Melton-Mowbray: for their Iron Sack-Truck, with wood handles; invented and manufactured by Warren Sharman, of Melton-Mowbray.

†Arthur Crosskill, of Beverley: for his Specimens of Portable Farm-Railway; invented and improved by William Crosskill, and manufactured by the Exhibitor.

†Young, Peddie, and Co., of Edinburgh: for their Corn-Rick Stand, 12 feet in diameter, with wrought-iron framing and cast-iron pillars; improved and manufactured by themselves.

†Smith, Brothers, and Co., of Stirling Road, Glasgow: for their Cart and Cattle Weighing-Machine; invented, improved, and manufactured by themselves.

*Barrett, Exall, and Andrewes, of Reading: for their Six-horse power Portable Steam-Engine; invented, improved, and manufactured by themselves.

*Richard Hornsby and Son, of Spittlegate: for their Eight-horse power Portable Steam-Engine; invented, improved, and manufactured by themselves.

*Ransomes and Sims, of Ipswich: for their Seven-horse power Portable Steam-Engine; invented, improved, and manufactured by themselves.

*Richard Garrett and Son, of Leiston: for their Seven-horse power Portable Steam-Engine; invented, improved, and manufactured by themselves.

†Alfred Crosskill, of Beverley: for his Six-horse power Portable Steam-Engine; improved by William Crosskill; and manufactured by the Exhibitor.

†Joseph Lee, of Stonnall, Walsall, Staffordshire: for his Seven-horse power Portable Steam-Engine; invented, improved, and manufactured by himself.

*Clayton, Shuttleworth, and Co., of Lincoln: for their Eight-horse power Fixed Steam-Engine; invented, improved, and manufactured by themselves.

*Tuxford and Sons, of Boston: for their Six-horse power Fixed Steam-Engine; invented by Weston Tuxford, of Boston; and manufactured by themselves.

†William Dray and Co., of Swan Lane, London: for their Eight-horse power Fixed Steam-Engine; invented, improved, and manufactured by themselves.

*Richard Garrett and Son, of Leiston, Saxmundham: for their Fixed Barn-Works, or complete set of machinery for Thrashing and Dressing all kinds of Grain, and delivering it at one operation into sacks fit for market; invented, improved, and manufactured by themselves (see "Medals").

*Clayton, Shuttleworth, and Co., of Lincoln: for their Combined Portable Thrashing, Straw-shaking, Riddling, Winnowing, Chaff-separating, and Barley-horning Machine; invented, improved, and manufactured by themselves (see "Medals").

*Edward and Thomas Humphries, of Pershore, Worcestershire: for their Combined Thrashing, Shaking, Riddling, Winnowing, and Barley-horning Machine; invented, improved, and manufactured by themselves.

*Tuxford and Sons, of Boston: for their Combined Thrashing, Shaking, and Winnowing-Machine, with Elevators and Barley Aveller of improved construction attached; invented by Weston Tuxford, and manufactured by themselves.

*William Newzam Nicholson, of Newark-upon-Trent: for his Corn-dressing Machine, for small occupations; invented, improved, and manufactured by himself.

*Charles Bunting, of Halfway Houses, near Carlisle: for his Winnowing-Machine, commended as a "Corn-dressing" Machine; improved and manufactured by himself.

*James Hayes, of Elton, near Oundle: for his Grinding-Mill, fitted with Derbyshire-Peak Stones, and worked by either horse or steam power; grinding barley into soft meal for pigs, splitting beans and oats, and adapted for the farmer's use; invented, improved, and manufactured by himself.

†Alfred Crosskill, of Beverley: for his Portable Corn-Mill, for steam or water power; improved by William Crosskill, and manufactured by the Exhibitor.

*William Prockter Stanley, of Peterborough: for his Roller-Mill, for crushing linseed, oats, barley, malt, gold-of-pleasure, beans, and Indian-corn; invented, improved, and manufactured by himself.

†Phillips and Woods, of Brandon and Stowmarket: for their Crushing-Mill, for linseed, oats, barley, and malt; invented, improved, and manufactured by James Woods, of Stowmarket.

*William Dray and Co., of Swan Lane, London: for their Chaff-cutting Machine, No. 3; to be worked by horse or steam power; invented, improved, and manufactured by themselves.

†Barrett, Exall, and Andrewes, of Reading: for their Iron Chaff-cutter, for horse or steam power, marked O F; invented, improved, and manufactured by themselves.

†Richmond and Chandler, of Salford, Manchester: for their Chaff-cutting Machine, No. 4 B, to be worked by hand, horse, water, or steam power; invented, improved, and manufactured by themselves.

†Richard Garrett and Son, of Leiston: for their Chaff-Cutter, for horse or steam power; improved and manufactured by themselves.

*James Cornes, of Barbridge, near Nantwich: for his Hand Chaff-Cutting Machine, No. 9, with two knives; invented by John Cornes, and improved and manufactured by the Exhibitor.

*Smith and Ashby, of Stamford: for their No. 5 Ten-inch Safety Two-knived Hand Chaff-Cutter; invented, improved, and manufactured by themselves.

†Hill and Smith, of Brierly Hill, Dudley: for their Hand Chaff-Cutter; invented by James Cornes, and improved and manufactured by themselves.

†CALDON and MACKINNEL, of Dumfries: for their Cart Turnip-Cutting Machine; invented, improved, and manufactured by themselves.

*HUGH CARSON, of Warminster: for his Hand Turnip-Cutter, No. 1; invented by Edmund Moody, late of Maiden-Bradley, and improved and manufactured by the Exhibitor.

†BARNARD and BISHOP, of Norwich: for their Root-Grater or Turnip-Cutter: invented by G. Bushe, of Lismore, and Dr. Barter, of Blarney; improved and manufactured by the Exhibitors.

†RICHMOND and CHANDLER, of Salford: for their Turnip-Cutter; invented and improved by Edmund Moody, and manufactured by B. Samuelson, of Banbury.

*RICHARD GARRETT and SON, of Leiston: for their Hand-Machine for Pulping Roots: invented, improved, and manufactured by themselves.

†ARTHUR LYON, of Windmill Street, Finsbury: for his Cutting-Machines for cutting meat and vegetables, and applicable for general household purposes; invented, improved, and manufactured by himself.

†SAMUEL NYE, of Wardour Street, Soho: for his Mincing-Machine, for mincing meat, vegetables, fruit, &c.; invented by the Exhibitor and John Gilbert, of Wardour Street, and improved and manufactured by the Exhibitor.

*RICHARD HORNSBY and SON, of Spittlegate: for their Double Cake-Breaking or Crushing Machine for every variety of oil-cake for beasts and sheep, and of rape-cake for manure; invented, improved, and manufactured by themselves.

†ARTHUR CROSSKILL, of Beverley: for his Large-sized Cake-Breaker, for every variety of oil-cake or rape-cake; improved by William Crosskill, and manufactured by the Exhibitor.

†ROBERT TINKLER, of Penrith: for his Barrel-Churn; invented, improved, and manufactured by himself.

*WILLIAM DRAY and Co., of Swan Lane, London: for their American Churn; invented by J. Dalphin, of the United States of America; and improved and manufactured by themselves.

†ALFRED CROSSKILL, of Beverley: for his Portable Saw-Mill; improved by William Crosskill, and manufactured by the Exhibitor.

*WILLIAM COULSON, of Fetter Lane, York: for his Combined Machine for Boring and Mortising naves, felloes, gates, posts, &c.; invented and manufactured by himself. (See "Medals.")

†WILLIAM DRAY and Co., of Swan Lane, London: for their Portable Farm Bench and Vice; invented, improved, and manufactured by themselves.

†WILLIAM NEWZAM NICHOLSON, of Newark-upon-Trent: for his Pair of Machines for Washing and Wringing; improved and manufactured by himself.

†WILLIAM PEARSON and Co., of Leeds: for their Washing-Machine, for washing, wringing, and mangling; improved and manufactured by themselves.

†WILLIAM NEWZAM NICHOLSON, of Newark-upon-Trent: for his Cottage Cooking-Range or Stove; invented, improved, and manufactured by himself.

*HERNULEWICZ, MAIN, and Co., of Glasgow: for their Strong Wrought-Iron Gate for field purposes, hung to cast-iron pillars, and self-shutting; invented and manufactured by themselves.

†HILL and SMITH, of Brierly Hill, Dudley: for their Wrought-Iron Field-Gate; invented and manufactured by themselves.

†HILL and SMITH, of Brierly Hill: for their Wrought-Iron Sheep-Trough, on wheels, and so constructed that the sheep can neither jump over it nor upset it; invented and manufactured by the Exhibitors.

†HILL and SMITH, of Brierly Hill: for their set of Improved Cast-iron Stable-Furniture; invented, improved, and manufactured by themselves.

The mark * signifies "HIGHLY COMMENDED;" the mark † "COMMENDED," by the Judges.

JAMES HUDSON,
Secretary.

London, December, 1855.

Essays and Reports.—PRIZES FOR 1856.—All Prizes of the Royal Agricultural Society of England are open to general competition. Competitors will be expected to consider and discuss the heads enumerated.

I. FARMING OF BEDFORDSHIRE.

FIFTY SOVEREIGNS will be given, by the Society, for the best Report on the Farming of Bedfordshire.

1. Physical characteristics of the county; climate, surface, rivers; geological subdivisions and peculiarities, noting differences, if any, of farm-practice traceable thereto.
2. Agricultural divisions; proportion of meadow, pasture, and arable; peat land; ordinary course of cropping on light and on heavy soils; treatment of clays; drainage; irrigation; dairy practice; farms of particular note; markets; population.
3. Notice of former agricultural reports of the county; improvements since Bachelor's survey; further changes needed.

II. KEEPING QUALITIES OF TURNIPS.

TWENTY SOVEREIGNS will be given for the best Essay on the production of Turnips possessing good keeping qualities, and their preservation to a late period of the season.

1. Kinds best adapted for storing.
2. Keeping qualities; how far affected by nature of soil; by early or late sowing; by heavy dressings; by special kinds of tillage; by the character of the season.
3. Drawing, and storing.

III. SPRING-FEED CROPS.

TEN SOVEREIGNS will be given for the best Essay on Spring-feed Crops, with special reference to early growth.

IV. DEEPENING THE STAPLE SOIL.

TWENTY SOVEREIGNS will be given for the best Essay on the different mechanical modes of Deepening the Staple soil, in order to give it the full benefit of atmospheric influence.

1. Deep-ploughing, comparative effect of, at springtime and autumn.
2. Subsoiling, especially upon lands recently drained.
3. Trench-ploughing; forking, digging, &c.
4. Is pulverization sufficient without inversion of the soil?

V. ATMOSPHERIC ACTION ON NEWLY-DEEPENED SOIL.

FORTY SOVEREIGNS will be given for the best Essay on the Chemical Results superinduced in Newly-deepened Soil by Atmospheric Action.

1. Effect of frost and alternations of temperature.
2. Of rain and of its passage through newly-exposed virgin soil.

3. Results produced by exposure to light.
4. Comparative absorptive power of old and newly-raised soils.
5. Changes in the oxides of iron, &c.

VI. FARM-ROADS.

TEN SOVEREIGNS will be given for the best Essay on the Construction and Maintenance of Farm-roads, with special reference to clay lands.

VII. ROOTS OF THE WHEAT-PLANT.

TWENTY SOVEREIGNS will be given for the best Essay on the Roots of the Wheat-plant, describing their growth and development.

1. Characteristics of roots of Autumn and Spring sown wheats.
2. Acclimatization.
3. Development, to what extent affected by top dressings at various periods of growth.
4. Lifting action of frost, commonly called "throwing out."

VIII. CONSTRUCTION OF LABOURERS' COTTAGES.

TWENTY SOVEREIGNS will be given for the best Essay and Plans for the Construction of Labourers' Cottages, with special reference to domestic convenience.

1. Arrangement of rooms and internal fittings.—2. Economy of warmth.—3. Ventilation.—4. Drainage.

IX. BRINGING MOORLAND INTO CULTIVATION.

TWENTY SOVEREIGNS will be given for the best Account of the different modes of bringing Moorland into Cultivation, based on practical experience, and specifying the methods pursued, the expense per acre, and the results ascertained; regard being had to subsoil, locality, and elevation.

1. Drainage.—2. Fencing.—3. Cultivation.—4. Course of cropping.

X. ANY OTHER AGRICULTURAL SUBJECT.

TEN SOVEREIGNS will be given for the best Essay or Report on any other Agricultural subject.

The Reports or Essays competing for these Prizes must be sent to the Secretary of the Society, at 12, *Hanover Square, London, on or before March* 1, 1856. *Contributors of Papers are requested to retain Copies of their Communications, as the Society cannot be responsible for their return.*

RULES OF COMPETITION FOR PRIZE ESSAYS.

1. All information contained in Prize Essays shall be founded on experience or observation, and not on simple reference to books or other sources. Competitors are requested to use foolscap or large letter paper, and not to write on both sides of the leaf.

2. Drawings, specimens, or models, drawn or constructed to a stated scale, shall accompany writings requiring them.

3. All competitors shall enclose their names and addresses in a sealed cover, on which only their motto, the subject of their Essay, and the number of that subject in the Prize List of the Society, shall be written.*

4. The President or Chairman of the Council for the time being shall open the cover on which the motto designating the Essay to which the Prize has been awarded is written, and shall declare the name of the author.

5. The Chairman of the Journal Committee shall alone be empowered to open the motto-paper of any Essay not obtaining the Prize, that he may think likely to be useful for the Society's objects; with a view of consulting the writer confidentially as to his willingness to place such Essay at the disposal of the Journal Committee.

6. The copyright of all Essays gaining Prizes shall belong to the Society, who shall accordingly have the power to publish the whole or any part of such Essays; and the other Essays will be returned on the application of the writers; but the Society do not make themselves responsible for their loss.

7. The Society are not bound to award a prize unless they consider one of the Essays deserving of it.

8. In all reports of experiments the expenses shall be accurately detailed.

9. The imperial weights and measures only are those by which calculations are to be made.

10. No prize shall be given for any Essay which has been already in print.

11. Prizes may be taken in money or plate, at the option of the successful candidate.

12. All Essays must be addressed to the Secretary, at the house of the Society.

* Competitors are requested to write their motto on the enclosed paper on which their names are written, as well as on the outside of the envelope.